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THESIS

TRI-LEVEL OPTIMIZATION OF CRITICAL INFRASTRUCTURE RESILIENCE

by

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September 2009

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We introduce a new way to perform network analysis on critical infrastructure that is superior to Risk Analysis and Management for Critical Asset Protection (RAMCAP), currently used by the Department of Homeland Security. We introduce the idea of a Design-Attack-Defend (DAD) model that determines the optimal defense plan for a critical infrastructure network within a specified budget constraint. Design-Attack-Defend first determines worst-case attacks and then determines where to defend or build additional infrastructure that will maximize the surviving efficiency of the infrastructure after a malicious attack or natural disaster. Design-Attack-Defend ensures that the defense plan suggested is optimal to a range of attacks, out of all possible defense plans, within budget constraints. The Design-Attack-Defend will always give a solution at least as good as RAMCAP and as a simpler, bi-level Attacker-Defender model—and in many cases it can be expected to suggest a better plan for where to defend or build additional critical infrastructure. We demonstrate with a model of the Western U.S. railroad network.

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TRI-LEVEL OPTIMIZATION OF CRITICAL INFRASTRUCTURE RESILIENCE

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ABSTRACT

We introduce a new way to perform network analysis on critical infrastructure that is superior to Risk Analysis and Management for Critical Asset Protection (RAMCAP), currently used by the Department of Homeland Security. We introduce the idea of a Design-Attack-Defend model that determines the optimal defense plan for a critical infrastructure network within a specified budget constraint. Design-Attack-Defend first determines worst-case attacks and then determines where to defend or build additional infrastructure that will maximize the surviving efficiency of the infrastructure after a malicious attack or natural disaster. Design-Attack-Defend ensures that the defense plan suggested is optimal to a range of attacks, out of all possible defense plans, within budget constraints. The Design-Attack-Defend will always give a solution at least as good as RAMCAP and as a simpler, bi-level Attacker-Defender model—and in many cases it can be expected to suggest a better plan for where to defend or build additional critical infrastructure. We demonstrate with a model of the Western U.S. railroad network.

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LIST OF ACRONYMS AND ABBREVIATIONS

AD	Attacker-Defender Model
DAD	Design-Attack-Defend Model
DHS	Department of Homeland Security
GAMS	Generic Algebraic Modeling Software
PRA	Probabilistic Risk Analysis
NIAC	National Infrastructure Advisory Council
NIPP	National Infrastructure Protection Plan
RAMCAP Risk	Analysis and Management for Critical Asset Protection
TFE	Twenty Foot Equivalent
TSA	Transportation Security Administration
TSI	Transportation Security Incident

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EXECUTIVE SUMMARY

We introduce a Design-Attack-Defend (DAD) algorithm for critical infrastructure vulnerability analysis. We compare three approaches to network analysis: the Risk and Management for Critical Asset Protection (RAMCAP) method used by the Department of Homeland Security (DHS), a bi-level Attacker-Defender algorithm, and tri-level Design-Attack-Defend. We simulate an attack on the U.S. West coast commercial rail system and calculate the resilience of the rail system after the attack using each of these assessment methods. We show that RAMCAP does not yield an optimal defense plan within a given budget constraint and that the Design-Attack-Defend model is a much more effective model to use when performing network analysis to determine where to defend infrastructure. In addition, the Design-Attack-Defend model always gives a defense plan at least as good as that of bi-level Attacker-Defender, and as the number of attacks and defenses increases, tri-level Design-Attack-Defend yields a significantly better defense plan than either RAMCAP or Attacker-Defender.

Design-Attack-Defend (DAD) finds the optimal defense plan for a critical infrastructure network using integer linear programming. DAD first finds the optimal attack using a bi-level Attacker-Defender algorithm. DAD then defends against that attack. DAD continues to iterate between designing affordable infrastructure enhancements, and attacking the network with the enhancements, eventually leading to an optimal defense strategy: The defense plan that DAD yields is an optimal defense plan within given budget constraints.

Design-Attack-Defend gives better advice than RAMCAP because RAMCAP performs no analysis of network performance following an attack or natural disaster. RAMCAP bases it defense plan solely on the flow of goods prior to an attack or natural disaster. Design-Attack-Defend performs better than bi-level Attacker-Defender because Attacker-Defender only looks at the worst-case attack and defends against that attack for a given, fixed infrastructure.

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I. INTRODUCTION

Since 9/11, federal, state, and local governments have been concerned with protecting our critical national infrastructure. The Presidential National Strategy for Homeland Security says:

> We cannot simply rely on defensive approaches and well-planned response and recovery measures. We will disrupt the enemy's plans and diminish the impact of future disasters through measures that enhance the resilience of our economy and critical infrastructure before an incident occurs. (White House, 2007)

Critical infrastructure includes "telecommunications, energy, banking and finance, transportation, water systems and emergency services" (PDD-63, 1998). The White House directive mandates that the federal government take steps to improve the resilience in our national infrastructure, where resilience is defined as, "The ability to reduce the magnitude and/or duration of disruptive events. It is the ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event" (NIAC, 2009).

Currently, Department of Homeland Security (DHS) guidance (NIPP, 2009) suggests the use of risk-based models for analyzing and remediating vulnerabilities in infrastructure systems, but such methods use simplistic assumptions that can result in ineffective defense plans. These models use Probabilistic Risk Analysis (PRA) that calculates risk by using the equation Risk=Vulnerability*Threat*Consequence, and then ranks the components of the critical infrastructure by their calculated risk. These models assume that reducing the individual risk of each component in the system brings down overall "system risk." This simple analysis ignores the interactions between components in complex systems, and has been shown to be inappropriate for developing resilient infrastructure (Cox, 2009).

This thesis provides a network analysis tool to suggest how limited funds should be used to protect, back up, or build additional components in an infrastructure network to increase resilience to malicious attacks or natural disasters. We calculate resilience as robustness of system operating cost to a range of attacks or to a worst-case attack or

disaster. We show how to maximize resilience of infrastructure networks and compare our result with the RAMCAP method, which the Department of Homeland Security (DHS) currently requires.

We propose two ways to assessing and improve infrastructure resilience: an Attacker-Defender model and the Design-Attack-Defend model. With Attacker-Defender, we first model the operation of a rail network using a multi-commodity network flow optimization that minimizes shipping costs (and penalties for non-delivery), then wraps an attacker model around it that discovers attacks to maximize the resulting minimum cost of operating the surviving network. Design-Attack-Defend extends Attacker-Defender by adding defensive decisions that minimize the resulting worst-case attack costs.

This thesis uses the Western U.S. railroad network as a case study. Our model of network operation prescribes how the network should be managed in any state to deal with disruptions, delays, and incremental costs inflicted by a Transportation Security Incident (TSI) on the U.S. West Coast commercial rail industry. The Transportation Security Administration (TSA) defines a TSI as, "A security incident resulting in significant loss of life, environmental damage, transportation system disruption, or economic disruption in a particular area" (TSA, 2009). We offer an assessment tool that is more reliable than PRA in identifying vulnerabilities of networks and can help policy makers allocate money for defending or adding additional infrastructure to a network.

A. OPERATIONAL ENVIRONMENT

The Western U.S. rail network is a vital resource for moving large amounts of supplies, such as food, water, and fuel, to large population centers and for moving large amounts of heavy equipment for both military and disaster response organizations. In its national Rail and Infrastructure Study, the Department of Transportation (DOT) estimates that the demand for rail freight transportation, measured in tonnage, will nearly double by 2035 (DOT, 2008). It is important to maintain the ability to move supplies via the rail network in order to respond quickly to an unforeseen event. Figure 1 shows the location of the existing railroads in California, a subset of the Western U.S. railroad network.

Figure 1. Diagram of California Component of the Western U.S. Railroad Network

The current Western U.S. railroad network was not designed to withstand a malicious attack, and as a result, is a prime target for an adversary with limited means to cause significant damage. The existing studies of rail transportation requirements and possible expansions do not take into account the impact of a TSI (DOT, 2008). Rail is a key infrastructure because, for example, the majority of the nation's major seaports, which are responsible for 90 percent of the imports and exports to the U.S. at an annual value of $800 billion, are connected to major distribution cities by railroads (BTS, 2008). In addition, the rail network acts as a vital resource to the military by moving large amounts of heavy equipment and ordinance to military bases inside the U.S. Our rail infrastructure is a prime example of a system designed with no regard to resilience, having just enough capacity to work under normal operating conditions, and extremely

vulnerable to even a moderate amount of disruption. This infrastructure was designed to convey freight at competitive costs, not to resist attacks by intelligent terrorists bent on maximizing operational disruption.

B. MODELS DISCUSSED

For rail systems, the RAMCAP calculated risk is proportional to the amount of flow on each arc (an arc is a length of rail connecting two cities) (Alion Science and Technology Corporation, 2009). RAMCAP recommends defending the arcs in decreasing order of rank until available funds for defenses are depleted. RAMCAP performs no analysis of network function after an attack, nor does it consider the influence of adding new components to the critical infrastructure.

Our proposed Attacker-Defender algorithm determines the locations of the worst-case attacks for various levels of attacker effort, and the resulting responding optimal flows over the damaged network. To determine the best defense using Attacker-Defender, we first allow the enemy one attack and then defend the arc that corresponds to the worst-case single attack by making that arc invulnerable. Once that arc is defended, we then run the Attacker-Defender algorithm on the new defended network to determine the operating cost of the network after attacking the defended network.

On the second run, the number of attacks is set to a constant value; for our analysis, we set the maximum number of attacks to five. We then allow the defender to increase the number of defenses, which means increasing the number of invulnerable arcs with the given number of attacks, held constant, and record the operating cost of the network after each new defense is added. Attacker-Defender does not consider building additional infrastructure, but instead only allows for hardening of existing infrastructure to render it essentially invulnerable.

Our Design-Attack-Defend model is a tri-level model that determines how best to design against a worst-case attack (as determined from the bi-level Attacker-Defender model) in response to that defense. We solve Design-Attack-Defend by determining a worst-case attack in the presence of no defense. We then choose a defense plan (that either protects existing infrastructure or adds new infrastructure) that is robust, i.e., that

minimizes the resulting damage that would result from any set of attacks seen so far. We repeat attacking and defending until the cost of operating the network after the worst-case attack and defense converge.

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II. ATTACKER-DEFENDER AND DESIGN-ATTACK-DEFEND MODELS OF INFRASTRUCTURE RESILIENCE

A. ATTACKER-DEFENDER MODEL

For any fixed number of attacks, our two-level Attacker-Defender (AD) model is formulated to determine the set of arcs to attack that maximizes the resulting minimum operating cost in the network (Brown et al., 2005).

1. Mathematical Formulation

Sets

$n \in N$	nodes in network (alias: i,j,p)
$(i, j) \in A$	arcs in network

Data

b_i^p	supply of commodity p at city i
u_{ij}	capacity on arc $(i, j) \in A$
c_{ij}	cost on arc $(i, j) \in A$
q_{ij}	penalty cost on arc $(i, j) \in A$, if attacked
$maxAttacks$	max number of attacks allowed

Decision Variables:

X_{pij}	flow on arc (i, j) with commodity p
Y_{ij}	= 1 if arc (i, j) attacked

Formulation (AD):

$$\max_Y \min_X \sum_p \sum_{(i,j)\in A} (c_{ij} + q_{ij} Y_{ij}) X_{pij} \qquad \text{(AD1)}$$

Subject to:

$$\sum_{j:(i,j)\in A} X_{pij} + \sum_{j:(j,i)\in A} X_{pji} = b_i^p \quad \forall i, p \qquad \text{(AD2)}$$

$$0 \le \sum_p X_{pij} \le u_{ij} \quad \forall (i, j) \in A \qquad \text{(AD3)}$$

$$\sum_{(i,j)\in A} Y_{ij} \le maxAttacks \qquad \text{(AD4)}$$

$$Y_{ij} \in \{0,1\} \qquad \text{(AD5)}$$

Discussion:

The objective function, (AD1), calculates the cost of operating the network after an attack occurs. Constraint (AD2) ensures balance of flow to all supply and demand nodes, for each commodity. Constraint (AD3) ensures that the flow on arc (i, j) does not exceed the capacity of arc (i, j). Finally, constraint (AD4) limits the maximum number of attacks to the user-specified limit, and stipulations (AD5) require the attacks to be binary.

2. Planning Defenses Using AD

We now provide a heuristic algorithm to illustrate how we can determine reasonable defense plans for a range of defense plan sizes, *s*, between one and eleven arcs, using AD in response to an anticipated attack. For the purpose of illustration, we will evaluate all defense plans against the optimal resulting five-arc attack. (We could evaluate each defense plan against a range of attack sizes, and we have done so, but we choose a five-arc attack to illustrate our results over the range of defense plans.) To determine a reasonable set of *s* arcs to defend, we first solve AD allowing the attacker *s* arcs to attack. We then defend the *s* arcs he chose to attack by setting their q_{ij} values to zero. In order to evaluate the effectiveness of this defense, and to compare it to defenses of other sizes, we then solve the modified AD model for the optimal resulting five-arc attack.

For example, we first determine a one-arc defense by first running the Attacker-Defender algorithm with *maxAttacks* = 1. The Attacker-Defender algorithm will then report the worst-case single attack, which in our case is the arc from Los Angeles to Burbank. We then defend that arc by setting its attacked cost, $q_{ij} = 0$.

The second step is to attack the network with the newly-defended arc, allowing the enemy five attacks and recording the operating cost. This is done by setting *maxAttacks* = 5 and attacking the network (with the new defended arc having $q_{ij} = 0$). This gives us our first data point for the Attacker-Defender model allowing the operator to defend one arc against five attacks.

To determine two defenses, we first run the Attacker-Defender algorithm allowing the enemy two attacks; that is, setting *maxAttacks* = 2. The resulting worst-case attack is Los Angeles to Burbank and Los Angeles to Glendale. We then defend both arcs by setting their respective $q_{ij} = 0$. Next, we attack the new defended network, with both $q_{ij} = 0$, by running the Attacker-Defender model with *maxAttacks* = 5, and record the operating cost of the network after two defenses against five attacks. We continue this increasing the number of allowed defenses until there was no attack on the network that would increase the operating cost. The algorithm used is below:

1. For *s* = 1 to Given a fixed number of defenses (*numDefenses*)
    a. Solve AD for optimal attack by setting *maxAttacks* = *s*
    b. Protect the arcs that correspond to the worst-case attack by setting $q_{ij} = 0$
    c. Solve AD for optimal attack with defended arcs $q_{ij} = 0$ and *maxAttacks* = 5
    d. Record the operating cost of the network with *s* defenses and 5 attacks
    e. Set all $q_{ij} = 1$
2. End For Loop

B. DESIGN-ATTACK-DEFEND MODEL

We formulate the problem of designing a rail network that is resilient to attack as a Design-Attack-Defend (DAD) model (Brown et al., 2006), where we now introduce decision variables V that explicitly represent the (defender's) choice of arcs to protect or build in the network. For each arc (or potential arc) in the network, we introduce a set of defense options, indexed by d, that are available for that arc. The set of defense options for a given arc will always include a special option, d_0, which represents the arc in its current state. This special defense option is the "do-nothing" option for this arc, and choosing this option for an arc will not consume any defense budget we might impose. Any other defense option for that arc will have new arc data associated with choosing it, such as a new operating cost, a new capacity, and a new penalty cost.

1. Mathematical Formulation

<u>Sets:</u>

$n \in N$	nodes in network (alias: i,j,p)
$(i, j) \in A$	arcs in network
$d \in D$	defense options
k	attack iteration index
ℓ	defense iteration index

<u>Data:</u>

b_i^p	demand for commodity p at city i
u_{ij}^d	capacity on arc $(i, j) \in A$ under defense plan d
c_{ij}^d	cost on arc $(i, j) \in A$ under defense plan d
q_{ij}^d	penalty cost on arc $(i, j) \in A$, if attacked, under defense plan d
maxAttacks	maximum number of attacks allowed
maxDefenses	maximum number of non-d_0 defense options allowed

Decision Variables:

X_{pij}^{d} flow with destination *p* on arc (*i*, *j*) under defense plan *d* [*p*-units]

Y_{ij} = 1 if arc (*i*, *j*) attacked [binary]

V_{ij}^{d} = 1 if defense option *d* is chosen for arc (*i*, *j*) [binary]

Formulation:

$$\min_{V}\max_{Y}\min_{X} \sum_{p,d}\sum_{(i,j)\in A}(c_{ij}^{d}+q_{ij}^{d}Y_{ij})X_{pij}^{d} \qquad \text{(DAD1)}$$

$$s.t. \quad \sum_{d}\Big(\sum_{(i,j)}X_{pij}^{d}-\sum_{(j,i)}X_{pji}^{d}\Big)=b_{i}^{p} \qquad \forall\, i,p \qquad \text{(DAD2)}$$

$$\sum_{d}V_{ij}^{d}=1 \qquad \forall (i,j)\in A \qquad \text{(DAD3)}$$

$$0\le \sum_{p}X_{pij}^{d}\le u_{ij}^{d}V_{ij}^{d} \qquad \forall (i,j)\in A,d \qquad \text{(DAD4)}$$

$$\sum_{(i,j)\in A}Y_{ij} \le maxAttacks \qquad \text{(DAD5)}$$

$$\sum_{d\ne d_0,(i,j)\in A}V_{ij}^{d}\le maxDefenses \qquad \text{(DAD6)}$$

$$V_{ij}^{d}\in\{0,1\} \qquad \forall (i,j)\in A,d$$

$$Y_{ij}\in\{0,1\} \qquad \forall (i,j)\in A$$

$$X_{pij}^{d}\ge 0 \qquad \forall p\in N,(i,j)\in A,d$$

The objective function, (DAD1), calculates the operating cost of the network after an attack occurs. Constraint (DAD2) ensures balance of flow to all supply and demand nodes, for each commodity. Constraint (DAD3) requires that exactly one defense option be chosen for each component in the network. Of course, each arc has the “do-nothing” defense option, d_0, available; choosing this option for each arc in the network is a feasible, but probably sub-optimal, defense plan. Constraint (DAD4) ensures that the flow on arc (i,j) does not exceed the capacity of arc (i,j) for the chosen defense plan. Constraint (DAD5) limits the maximum number of attacks to the user specified limit.

Finally, constraint (DAD6) forces the model to defend arcs within the available budget constraints (represented here as a simple cardinality constraint).

Design-Attack-Defend determines the best place to protect existing infrastructure or build additional infrastructure that will minimize the cost of operating a network after a worst-case attack. Unfortunately, Design-Attack-Defend is not a linear program and cannot be solved using linear programming techniques. Therefore, we separate the model into a master problem that determines defenses and arc flows, and a subproblem that determines optimal attacks against any given (i.e., fixed) defense. We use a Benders Decomposition algorithm to solve the model.

2. Decomposition Algorithm to Solve DAD

Our algorithm for solving DAD considers a sequence of defense plans, solves AD to evaluate each of those defense plans, and keeps a record of every attack seen so far. It then determines a new, improved defense plan that is optimal against all attacks seen up to that point. The algorithm terminates when the AD model does not determine a new, effective attack, or when it cannot find any improvement to the best defense plan found so far.

At each Benders iteration, for any fixed defense plan, the subproblem (SUB) evaluates the worst-case attack plan for that defense by solving AD using the arc data for the defense options chosen for each arc.

a. Subproblem (SUB)

Given any fixed defense plan $\overline{V}_{ij}^{d}$, we define our subproblem to be AD with modified data.

<u>Calculated Data:</u>

$$\overline{q}_{ij} \equiv \sum_{d} q_{ij}^{d} \overline{V}_{ij}^{d}$$

$$\overline{c}_{ij} \equiv \sum_{d} c_{ij}^{d} \overline{V}_{ij}^{d}$$

$$\overline{u}_{ij} \equiv \sum_{d} u_{ij}^{d} \overline{V}_{ij}^{d}$$

Formulation SUB:

$$\max_{Y}\min_{X}\sum_{p}\sum_{(i,j)\in A}(\bar{c}_{ij}+\bar{q}_{ij}Y_{ij})X_{pij} \qquad \text{(SP1)}$$

Subject to:

$$\sum_{j:(i,j)\in A}X_{pij}+\sum_{j:(j,i)\in A}X_{pji}=b_i^p \quad \forall i,p \qquad \text{(SP2)}$$

$$0\le\sum_{p}X_{pij}\le\bar{u}_{ij} \qquad \forall(i,j)\in A \qquad \text{(SP3)}$$

$$\sum_{(i,j)\in A}Y_{ij}\le maxAttacks \qquad \text{(SP4)}$$

$$Y_{ij}\in\{0,1\} \qquad \text{(SP5)}$$

<u>Discussion</u>:

SUB determines the optimal attack for the current, fixed defense plan. It is a modified version of AD, using cost, capacity, and attack cost data as determined by that defense plan. We solve the model above the same way as AD. Once SUB finds the optimal attack, that attack is added to list of attacks seen so far and the MASTER problem is called to determine a new optimal defense plan.

b. Master Problem (CREATE_DEFENSE)

At iteration *k*, given the finite list of *k* attack plans found so far by SUB, $\bar{Y}_{ij}^k$, the master problem, CREATE_DEFENSE, determines the optimal defense that minimizes the resulting operating cost under the worst of these attacks. Therefore, each attack provides a lower bound on the value of the defense plan chosen. Because the flows are chosen *after* the attacker chooses an attack, each of the *k* attacks has its own set of arc flow variables to model the optimal response. The master problem follows.

Sets:

$n \in N$	nodes in network (alias: *i*,*j*,*p*)
$(i, j) \in A$	arcs in network
$d \in D$	defense options
k	attack iteration index
ℓ	defense iteration index

Data:

b_i^p	demand for commodity p at city i
u_{ij}^d	capacity on arc $(i, j) \in A$ under defense plan *d*
c_{ij}^d	cost on arc $(i, j) \in A$ under defense plan *d*
q_{ij}^d	penalty cost on arc $(i, j) \in A$, if attacked, under defense plan *d*
maxDefenses	maximum number of non-d_0 defense options allowed

Decision Variables:

XK_{pij}^{dk}	flow with destination *p* on arc (*i*, *j*) under defense *d* after attack *k*
$\overline{Y}_{ij}$	= 1 if arc (*i*, *j*) attacked [binary]
V_{ij}^d	= 1 if defense option *d* is chosen for arc (*i*, *j*) [binary]

Formulation CREATE_DEFENSE:

$$\min_V Z_{DEF}$$

Subject to:

$$Z_{DEF} \geq \sum_{p,d} \sum_{(i,j)} (c_{ij}^d + q_{ij}^d \overline{Y}_{ij}^k) XK_{pij}^{dk} \qquad \forall k \qquad \text{(CD1)}$$

$$\sum_d \left(\sum_{j:(i,j)\in A} XK_{pij}^{dk} - \sum_{j:(j,i)\in A} XK_{pji}^{dk} \right) = b_i^p \qquad \forall p,i,k \qquad \text{(CD2)}$$

$$\sum_d V_{ij}^d = 1 \qquad \forall i,j \in A \qquad \text{(CD3)}$$

$$0 \leq \sum_{p} XK_{pij}^{dk} \leq u_{ij}^{d} V_{ij}^{d} \qquad \forall d,k,i,j \qquad \text{(CD4)}$$

$$\sum_{d,(i,j)\in A} V_{ij}^{d} \leq maxDefenses \qquad \text{(CD5)}$$

Discussion:

The objective function of the CREATE_DEFENSE model minimizes the cost of operating the network. The Constraint (CD1) bounds the cost of operating the network with the defense plan using the k^{th} attack found by SUB. Constraint (CD2) maintains balance of flow for each node, for each commodity, under each attack *k*, and ensures the network meets all demand. Constraint (CD3) forces the model to choose only one defense plan for each component on the network. Constraint (CD4) ensures that the new flow on the new network does not exceed the capacity of the arc for the given defense plan, and for each attack *k*. Constraint (CD5) ensures the total cost of the additional infrastructure does not exceed the available funds, again, represented here as a simple cardinality constraint.

c. Algorithm for DESIGN-ATTACK-DEFEND

Design-Attack-Defend solves CREATE_DEFENSE after every new attack found by SUB. After determining a new defense plan by solving CREATE_DEFENSE, our decomposition then solves the subproblem (SUB) to find the optimal attack against the new defense plan, and the optimal response to that attack given the additional infrastructure created by CREATE_DEFENSE. It alternates between CREATE_DEFENSE and SUB thereby creating new infrastructure and then attacking the new network until the costs of attacking and defending the network converge, and we have found the optimal placement of additional infrastructure that will minimize the cost of operating the network for all possible attacks. Below is a list of the parameters used by the DAD model, and our solution procedure.

Variables:

v_ub	upper bound on current defense plan
v_lb	lower bound on current defense plan
max_iter	maximum iterations
defense_tol	acceptable optimality gap for solutions to DAD
attack_tol	acceptable relative optimality gap for SUB
$\bar{Y}_{ij}^{k}$	fixed attack at iteration *k*
$\bar{V}_{ij}^{d}$	fixed defense plan

1. Pseudo code for the Design-Attack-Defend Algorithm:

$\bar{Y}_{ij}^{k} = 0 \;\; \forall (i,j) \in A, \forall k$
$\bar{V}_{ij}^{d} = 0 \;\; \forall (i,j) \in A, \forall d$
v_ub = INF
v_lb = -INF
k = 1
While (*v_ub* – *v_lb*) > *defense_tol***v_lb* and *k*<*max_iter*
    Solve SUB to obtain *attack_tol*-optimal solution $\bar{Y}$ with value Z and upper bound Z_UB
    If *v_ub* > Z_UB:
        v_ub = Z_UB
        $v_{ij}^{d*} = \bar{V}_{ij}^{d}$ for all $(i,j) \in A$, for all *d*
    Set $\bar{y}_{ij}^{k} = \bar{Y}_{ij}$ for all $(i,j) \in A$
    Solve CREATE_DEFENSE to obtain optimal solution $\bar{V}$ with value Z_{Def}
    If Z_{Def} > *v_lb*
        v_lb = Z_{Def}
    k=k+1
End While

Design-Attack-Defend offers an optimal or near-optimal (for difficult instances) solution for determining where to build additional critical infrastructure. As is shown in the analysis below, it is not possible for Attacker-Defender or RAMCAP to

give a solution that is better than the Design-Attack-Defend algorithm. It is important to note that if there is no attacker, that is *numAttacks* = 0, then the Design-Attack-Defend model reduces to a classis multi-commodity network design problem (Balakrishnam et al., 1997). The complete GAMS code (GAMS, 2009) is available from the author or his thesis advisors.

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III. DESIGN-ATTACK-DEFEND RESULTS

A. CASE STUDY: WESTERN U.S. RAILROAD NETWORK

Appendix A provides the graph underlying the Western U.S. railroad network; there are 96 nodes, representing stations along a rail line or the junction of more than one rail line, and 225 arcs, representing segments of track connecting the nodes. Table 1 is a sample of the data in Appendix A. Every node appears at least once in either the "Tail" column or the "Head" column. The "Tail" column is the city from which goods are leaving and the "Head" column is the adjacent city on the network where the goods are going. Every arc in our graph also has an associated cost, capacity, and additional cost if attacked. If no defensive preparations have been made for an arc, we say that the defender chose the "do-nothing" defense option for that arc, and then its per-unit cost for traffic is simply one dollar per pound. Likewise, its capacity is 2,000,000 pounds per day, and, if it is attacked, the additional penalty cost on shipping goods across that arc is $101 per pound. If the defender chooses to protect the arc, then attacks have no effect, and so the additional penalty for goods shipped across such an arc is zero. In more complex scenarios, several defense options can be defined for each arc, each with its own cost, capacity, and attack penalty.

Tail	Head
Anaheim	Irvine
Anaheim	Norwalk
Anaheim	Santa_Ana
Anaheim	Fullerton
Antioch_Pittsburgh	Martinez
Antioch_Pittsburgh	Stockton
Bakersfield	Palmdale_Airport

Table 1. Sample California Commercial Rail Graph Adjacencies.

Appendix B shows the complete demand matrix for the Western U.S. railroad network. Each column in Appendix B shows demand node, and each row is the supply node. Table 2 provides an excerpt of this demand data. Each entry is notional data

estimated based on the populations of the respective cities, and is proportional to the product of those two populations (U.S. Census, 2000).

	Albany	Anaheim	Antioch-Pit	Bakersfield	Barstow	Bellingham	Berkeley
Albany	12130	-5	-18	-7	-78	-694	-16
Anaheim	-1995	243851	-362	-133	-1553	-13840	-319
Antioch-Pittsburgh	-551	-28	67230	-37	-429	-3820	-88
Bakersfield	-1501	-75	-273	183524	-1169	-10418	-240
Barstow	-128	-6	-23	-9	15607	-891	-21

Table 2. California Commercial Rail Demand.

For example, Albany has 12,130 pounds of goods to ship. From Albany, Anaheim has a demand of 5 pounds, Antioch-Pit has a demand of 18 pounds, and Bakersfield has a demand of 7 pounds.

B. RAMCAP

RAMCAP is a probabilistic risk analysis method that calculates risk using the equation *Risk=Vulnerability*Threat*Consequence*. RAMCAP ranks arcs by calculated risk. In the absence of any actionable intelligence regarding threat to individual components in our infrastructure, the standard approach in RAMCAP is to assume all threats are equal, and so, without loss of generality, “Threat”=1. We assume that any attack against undefended rail segments will be successful, and, therefore, that “Vulnerability”=1 as well. Finally, we must choose a single, scalar number for each arc to represent the consequence of losing it. The only reasonable consequence value we can calculate is the actual flow on each arc in the network when no components have been attacked, and so “Consequence”=flow on each arc. For rail systems, then, the risk of an arc is proportional to the flow on that arc; therefore, the arc with the highest flow is the most critical (Alion Science and Technology Corporation, 2009). The RAMCAP user then sorts arcs by amount of flow. RAMCAP suggests defending the arcs in decreasing order of flow until available resources run out. RAMCAP assumes that by protecting individual arcs in the network, the overall performance increases.

To determine the effectiveness of RAMCAP, we first evaluate the network performance after an attack, then we compare with performance before an attack. In order to determine the effectiveness of RAMCAP, we rank all of the components using the risk measure above, and then, for each number of defenses *numDef*, we make the top *numDef* components from that ranked list invulnerable, and evaluate that defense plan by running the Attacker-Defender model on that modified network. Figure 2 shows how network improves as the number of defenses increases using the RAMCAP defense plan. Notice that RAMCAP defense, allowing the enemy five attacks, has an 11.67% increase in cost after 18 defenses. The reason is, RAMCAP does not anticipate the best place for an attack and only adds defenses based on current flow before an attack. RAMCAP's inability to anticipate the enemy's worst attack for a given defense plan allows the enemy to find a weakness in the defense by analyzing possible flow after an attack, and to attack arcs in such a way as to minimize capability after an attack.

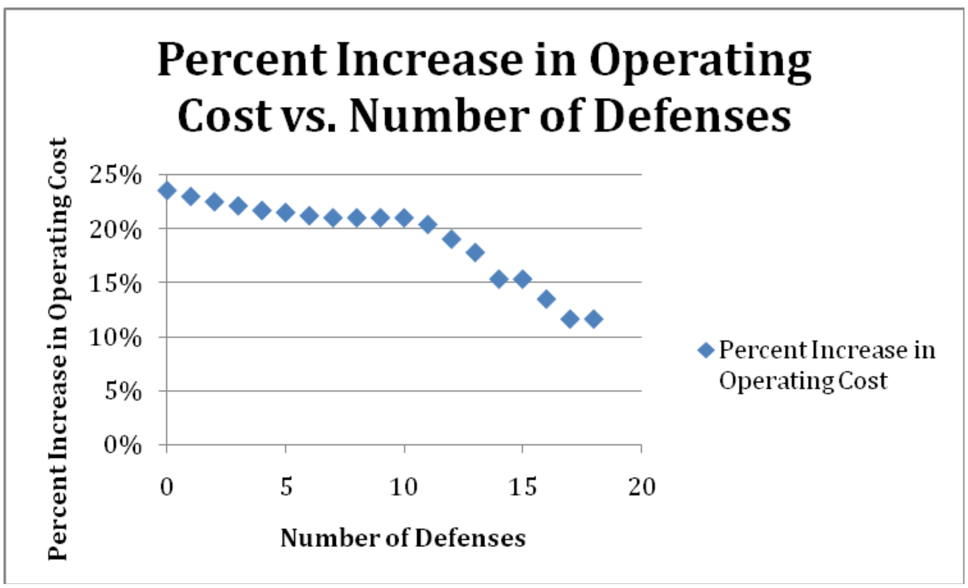

Figure 2. RAMCAP–Percent Increase in Operating Costs of Network vs. Number of Defenses

The optimal RAMCAP defense plan is in Table 3. We analyze the "optimal" (i.e., greedy, myopic heuristic) RAMCAP defense plan by setting the defenses in accordance with the optimal RAMCAP defense plan and then running the bi-level Attacker-Defender

model shown above to determine the percent degradation after five attacks versus the number of indicated defenses. Table 3 shows the RAMCAP defense plan.

Number of Defenses	**Head**	**Tail**
1	Sacramento	Stockton
2	Oroville	Marysville
3	Marysville	Sacramento
4	Chico	Oroville
5	Red Bluff	Chico
6	Dunsmuir	Redding
7	Redding	Red Bluff
8	Klamath Fall	Dunsmuir
9	Stockton	Modesto
10	Chemult	Klamath Fall
11	Merced	Fresno
12	Eugene	Chemult
13	Modesto	Merced
14	Albany	Eugene
15	Fresno	Bakersfield
16	Salem	Albany
17	Portland	Salem
18	Bakersfield	Glendale

Table 3. RAMCAP Defense Plan

The first column is the number of defenses; the head and tail column correspond to the head and tail of the arc that is added to the RAMCAP defense plan as the number of allowed defenses increases.

C. ANALYSIS OF THE ATTACKER-DEFENDER ALGORITHM

The Defense plan for the bi-level Attacker-Defender model is shown below:

1-6 Defenses	
Los Angeles	Burbank
Los Angeles	Glendale
Pomona	Los Angeles
Red Bluff	Chico
San Jose	Berkeley
Richmond	Martinez
7 Defenses	
Los Angeles	Glendale
Pomona	Los Angeles
Red Bluff	Chico
Richmond	Martinez
Santa Clarita	Los Angeles
Sylmar	Burbank
Union City	Oakland Airport
8 Defenses	
Los Angeles	Burbank
Los Angeles	Glendale
Redding	Dunsmuir
Richmond	Berkeley
San Bernardino	Pomona
Santa Clarita	Los Angeles
Tahoe	Roseville
Union City	Oakland Airport
9 Defenses	
Los Angeles	Glendale
Oroville	Marysville
Richmond	Martinez
Riverside	Oakland Airport
San Bernardino	Pomona
San Juan Capistrano	Irvine
Santa Clarita	Los Angeles
Sylmar	Burbank
Union City	Oakland Airport
10 Defenses	
Los Angeles	Glendale
Los Angeles	Industry
Norwalk	Industry
Oakland Airport	Industry
Oroville	Marysville
San Bernardino	Pomona
San Jose	Berkeley
San Jose	Redwood City
Sylmar	Burbank
Tahoe	Roseville
11 Defenses	
Glendale	Bakersfield
Los Angeles	Industry
Norwalk	Industry
Oakland Airport	Industry
Oroville	Marysville
Pomona	Los Angeles
Richmond	Berkeley
San Juan Capistrano	Irvine
San Luis Obispo	Salinas
Sylmar	Burbank
Tahoe	Roseville

Table 4. Defense Plans Determined by AD

The six-arc defense suggested by AD includes the first six arcs. *Note that the seven-arc defense does not contain the six-arc defense plan suggested by AD, and that, therefore, defense plans are not necessarily monotonic.* That is, there is no optimal ranking of defenses, and forcing such ranking, as RAMCAP would, is an unnecessary restriction of defense efforts that can lead to degraded results.

The columns correspond to the head and tail of the defended arc. As the number of defenses increases, the arcs that are defended change in accordance with the Attacker-Defender algorithm, and do so in a non-monotonic fashion. For example, the seven-arc defense suggested by AD does not include the six-arc defense as a proper subset. This means that there is no strict ranking of components to defend. AD suggests *sets* of components to defend, and those sets depend on the number of components to be defended.

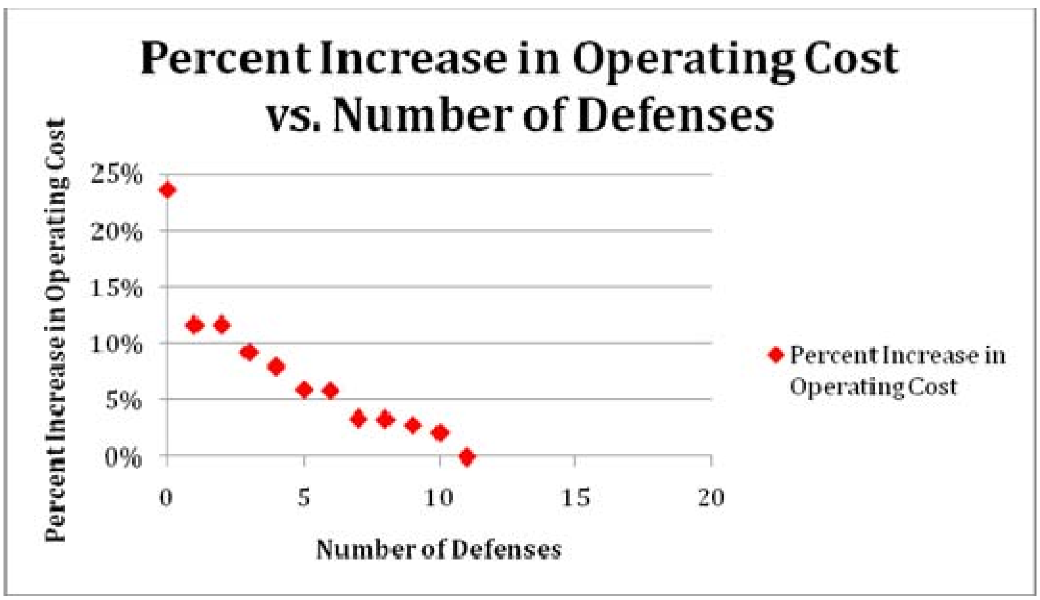

Figure 3. Percent Increase in Operating Costs of Network vs. Number of Defenses Using AD

Figure 3 shows how the optimal operating cost of the attacked network decreases as the number of defenses increase. The graph reveals a tremendous benefit to be gained by even one defense. Successive defenses are less effective, but still improve the resilience of the network. The graph shows that after eleven defenses, there is no

additional gain from additional infrastructure because the attacker has no effective five-arc attack against the optimal eleven-arc defense. The system is as robust as we need to make it for this attack scenario.

D. ANALYSIS OF THE DESIGN-ATTACK-DEFEND MODEL

Figure 4 shows the percent of degradation to the Western U.S. railroad network versus the number of allowed defenses using Design-Attack-Defend. The analysis below allows the enemy five attacks. Notice that the percent degradation versus the number of defenses decreases more rapidly than the defense plans created by RAMCAP and Attacker-Defender.

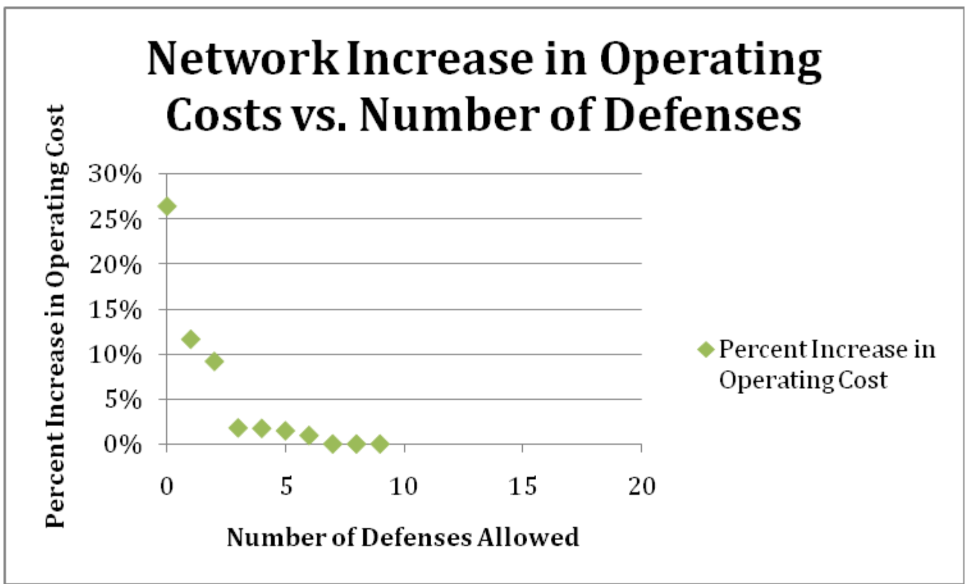

Figure 4. Network Increase in Operating Costs vs. Number of Defenses

As can be seen in Figure 4, the first defense improves the cost of moving goods on the Western U.S. railroad network by 10 percent. After three defenses, the rail network is only degraded 1.7% by five attacks. At seven defenses, there is no attack plan that consists of five attacks that can degrade flow on the rail network. Design-Attack-Defend is able to determine where the worst-case five-arc attack occurs, and ensure that goods can be shipped around all possible attacks in order to meet supply and demand. Table 5 shows how the defense plan responding to five attacks changes as the number of

affordable defenses increases. Note that, again, as the number of affordable defenses increases, the arcs defended do not appear in a priority order. That is, *sets* of arcs are chosen for defense, rather than individual arcs in any particular myopic order. This is more evidence that a strict ranking of defenses is a restriction of optimal behavior, and a restriction of unknown severity to the defender.

1 Defense:			**6 Defenses:**	
Industry	Los Angeles		Bakersfield	Glendale
2 Defenses:			Berkeley	San Jose
Bakersfield	Glendale		Burbank	Los Angeles
Marysville	Oroville		Industry	Los Angeles
3 Defenses:			Industry	Norwalk
Industry	Oakland		Martinez	Richmond
Martinez	Suisun Fair		**7 Defenses:**	
Marysville	Oroville		Bakersfield	Glendale
4 Defenses:			Berkeley	San Jose
Berkeley	San Jose		Burbank	Los Angeles
Chico	Red Bluff		Industry	Los Angeles
Industry	Los Angeles		Industry	Norwalk
Marysville	Oroville		Industry	Oakland Airport
5 Defenses:			Marysville	Oroville
Marysville	Oroville		**8 Defenses:**	
Industry	Los Angeles		Bakersfield	Glendale
Industry	Norwalk		Burbank	Sylmar
Industry	Oakland		Industry	Los Angeles
Roseville	Tahoe		Industry	Norwalk
			Industry	Oakland Airport
			Los Angeles	Pomona
			Martinez	Richmond
			Marysville	Oroville

Table 5. DAD Defense Plan

E. COMPARISON OF DESIGN-ATTACK-DEFEND VERSES ATTACKER-DEFENDER AND RAMCAP

Figure 5 compares the three network analysis methods. We base the analysis on allowing the enemy five attacks. The graph below shows the operating cost of the network after five attacks versus the number of defenses allowed using the indicated network analysis algorithms.

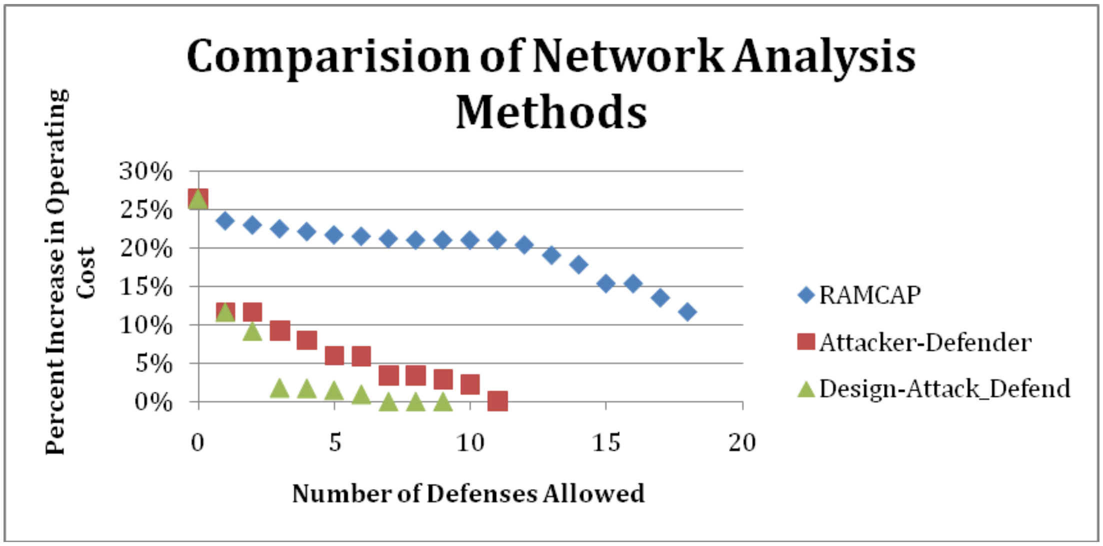

Figure 5. Comparison of Network Analysis Methods

As can be seen in Figure 5, Attacker-Defender outperforms RAMCAP. Attacker-Defender quickly determines the worst-case attack scenario and defends against it. As soon as Attacker-Defender is able to defend against all attacks, the amount of degradation to the network goes to zero. RAMCAP never yields a good defense, except when there is an unlimited defense budget. RAMCAP, and other PRA techniques, cannot consider adding additional infrastructure or redundant capacity, because they do not model infrastructure system function; they only evaluate individual components as they are currently configured. Design-Attack-Defend considers new infrastructure or additional capacity for additional infrastructure with minimal additional data. For this study, we did not use the additional infrastructure feature of Design-Attack-Defend, and chose to only make existing arcs invulnerable to offer a more direct comparison with RAMCAP.

If we were to consider additional infrastructure, Design-Attack-Defend would produce a solution at least as good as the defend-only option that we have chosen for our comparison. Therefore, Design-Attack-Defend can only perform better as we increase the number of additional components it can consider to reinforce or enhance the network.

For this problem, we have 96 nodes and 215 arcs, for the Attacker-Defender models there are 4,738 equations and 22,169 single variables for the cases where the attacker is given five attacks and the defender is allowed five defenses. For the Design-Attack-Defend model, there are 6,401 equations and 33,667 single variables for the five-attack and five-defense scenario.

Figure 5 also shows that the Design-Attack-Defend model provides significant improvement over the bi-level Attacker-Defender model for three to six defenses, and a significant improvement over RAMCAP for any number of defenses. If you can only afford to protect or add a few components, then Design-Attack-Defend is evidently the only reasonable way to determine how to create resilient infrastructure.

IV. CONCLUSIONS AND FOLLOW-UP RESEARCH

Risk Analysis and Management for Critical Asset Protection (RAMCAP) does not model the operation of the infrastructure being analyzed (in fact, it assumes that any notion of infrastructure "function" is summarized in the scalar value representing the consequence of losing an individual component). RAMCAP does not consider interactions among components in a complex critical infrastructure system, and it does not consider the worst-case possible attack an adversary could inflict against that infrastructure. Additionally, RAMCAP does not perform any analysis on the resilience of the new network after protecting existing infrastructure, and does not even consider the possibility of building additional infrastructure to enhance resilience.

Design-Attack-Defend is superior to RAMCAP and mere Attack-Defender models. Planning defenses based on Design-Attack-Defend will ensure maximum robustness to an attack, and will ensure the optimal flow of goods after a malicious attack or, as a side benefit, a natural disaster. The reason Design-Attack-Defend renders better advice than RAMCAP, is that RAMCAP simply defends the arcs with the highest amount of flow on them and does not analyze how a network is used after a malicious attack or natural disaster. Design-Attack-Defend performs better than the bi-level Attacker-Defender model because the Attacker-Defender model only looks at where the optimal attack will occur and does not consider how the optimal attacks will change in response to any given defense plan. The decision maker using the Attacker-Defender model can only defend the arcs that will cause the most damage when an attack occurs, and cannot perform any analysis on how to flow goods around an attack. Only Design-Attack-Defend shows how to flow goods around an attack and performs analysis on how the network is operated after an attack. For the Western U.S. railroad network, as presented here, we find that Design-Attack-Defend is clearly the most effective model to use when performing network analysis to determine where to defend infrastructure, but that the Attacker-Defender model is still better than PRA-based methods such as RAMCAP.

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APPENDIX A: WESTERN U.S. RAILROAD NETWORK ARC LIST

Tail	Head
Anaheim	Irvine
Anaheim	Norwalk
Anaheim	Santa_Ana
Anaheim	Fullerton
Antioch_Pittsburgh	Martinez
Antioch_Pittsburgh	Stockton
Bakersfield	Palmdale_Airport
Bakersfield	Fresno
Bakersfield	Wasco
Bakersfield	Glendale
Barstow	Needles
Barstow	Victorville
Berkeley	Richmond
Berkeley	San_Jose
Burbank	Los_Angeles
Burbank	Sylmar
Burbank_Airport	Santa_Clarita
Burbank_Airport	Van_Nuys
Chico	Oroville
Chico	Red_Bluff
Colfax	Truckee
Colfax	Tahoe
Corcoran	Hanford
Corcoran	Wasco
Davis	Suisun_Fairfield
Davis	Roseville
Davis	Sacramento
Dunsmuir	Redding
Escondido	University_City
Escondido	Murrieta
Fresno	Bakersfield
Fresno	Merced
Fresno	Madera
Fresno	Hanford
Fullerton	Anaheim
Fullerton	Los_Angeles
Gilroy	Salinas
Gilroy	San_Jose
Glendale	Bakersfield

Glendale	Los_Angeles
Hanford	Fresno
Hanford	Corcoran
Indio	Palm_Springs
Industry	Los_Angeles
Industry	Norwalk
Industry	Oakland_Airport
Irvine	Anaheim
Irvine	San_Juan_Capistrano
Irvine	Santa_Ana
Los_Angeles	Norwalk
Los_Angeles	Industry
Los_Angeles	Burbank
Los_Angeles	Fullerton
Los_Angeles	Glendale
Los_Angeles	Pasadena
Los_Angeles	Pomona
Los_Angeles	Santa_Clarita
Madera	Merced
Madera	Fresno
Martinez	Richmond
Martinez	Suisun_Fairfield
Martinez	Antioch_Pittsburgh
Marysville	Roseville
Marysville	Oroville
Marysville	Sacramento
Merced	Fresno
Merced	Modesto
Merced	Turlock_Denair
Merced	Madera
Modesto	Merced
Modesto	Stockton
Moorpark_Simi_Valley	Van_Nuys
Moorpark_Simi_Valley	Santa_Barbra
Murrieta	Escondido
Murrieta	Riverside
Needles	Barstow
Norwalk	Anaheim
Norwalk	Industry
Norwalk	Los_Angeles

Oakland	Oakland_Airport
Oakland_Airport	Union_City
Oakland_Airport	Oakland
Oakland_Airport	Riverside
Oakland_Airport	Industry
Oceanside	Solana_Beach
Oceanside	San_Clemente
Oroville	Marysville
Oroville	Chico
Palm_Springs	Indio
Palm_Springs	San_Bernadido
Palmdale_Airport	Sylmar
Palmdale_Airport	Bakersfield
Pasadena	Los_Angeles
Pomona	San_Bernadido
Pomona	Los_Angeles
Red_Bluff	Chico
Red_Bluff	Redding
Redding	Red_Bluff
Redding	Dunsmuir
Redwood_City	San_Jose
Redwood_City	SFO_Airport
Richmond	Berkeley
Richmond	Martinez
Riverbank	Stockton
Riverbank	Turlock_Denair
Riverside	Murrieta
Riverside	Oakland_Airport
Roseville	Sacramento
Roseville	Tahoe
Roseville	Davis
Roseville	Marysville
Sacramento	Stockton
Sacramento	Davis
Sacramento	Marysville
Sacramento	Roseville
Salinas	San_Luis_Obispo
Salinas	Gilroy
Salinas	San_Jose
San_Bernadido	Palm_Springs

San_Bernadido	Victorville
San_Bernadido	Pomona
San_Clemente	Oceanside
San_Clemente	San_Juan_Capistrano
San_Diego	Solana_Beach
San_Fransisco	SFO_Airport
San_Jose	Union_City
San_Jose	Redwood_City
San_Jose	Gilroy
San_Jose	Salinas
San_Juan_Capistrano	San_Clemente
San_Juan_Capistrano	Irvine
San_Luis_Obispo	Ventura
San_Luis_Obispo	Salinas
San_Diego	University_City
San_Jose	Berkeley
Santa_Ana	Irvine
Santa_Ana	Anaheim
Santa_Barbra	Moorpark_Simi_Valley
Santa_Barbra	Ventura
Santa_Clarita	Los_Angeles
Santa_Clarita	Burbank_Airport
SFO_Airport	Redwood_City
SFO_Airport	San_Fransisco
Solana_Beach	San_Diego
Solana_Beach	Oceanside
Sparks	Truckee
Stockton	Modesto
Stockton	Sacramento
Stockton	Antioch_Pittsburgh
Stockton	Riverbank
Suisun_Fairfield	Martinez
Suisun_Fairfield	Davis
Sylmar	Burbank
Sylmar	Palmdale_Airport
Tahoe	Colfax
Tahoe	Roseville
Truckee	Sparks
Truckee	Colfax
Turlock_Denair	Riverbank

Turlock_Denair	Merced
Union_City	San_Jose
Union_City	Oakland_Airport
University_City	San_Diego
University_City	Escondido
Van_Nuys	Burbank_Airport
Van_Nuys	Moorpark_Simi_Valley
Ventura	Santa_Barbra
Ventura	San_Luis_Obispo
Victorville	Barstow
Victorville	San_Bernadido
Wasco	Corcoran
Wasco	Bakersfield
Dunsmuir	Klamath_Falls
Klamath_Falls	Chemult
Chemult	Eugene
Eugene	Albany
Albany	Salem
Salem	Portland
Portland	Vancouver
Portland	Tacoma
Tacoma	Portland
Vancouver	Kelso_Longview
Kelso_Longview	Centrailia
Vancouver	Bingen_white_Salmon
Centrailia	Olympia_Lacey
Olympia_Lacey	Tacoma
Tacoma	Seattle
Seattle	Edmonds
Bingen_white_Salmon	Wilshram
Wilshram	Pasco
Pasco	Spokane
Spokane	Ephrata
Spokane	Hinkle
Hinkle	Spokane
Ephrata	Wenatchee
Wenatchee	Everett
Edmonds	Everett
Everett	Mt_Vernon
Mt_Vernon	Bellingham

Bellingham	Vancouver
Klamath_Falls	Dunsmuir
Chemult	Klamath_Falls
Eugene	Chemult
Albany	Eugene
Salem	Albany
Portland	Salem
Vancouver	Portland
Kelso_Longview	Vancouver
Centrailia	Kelso_Longview
Bingen_white_Salmon	Vancouver
Olympia_Lacey	Centrailia
Tacoma	Olympia_Lacey
Seattle	Tacoma
Edmonds	Seattle
Wilshram	Bingen_white_Salmon
Pasco	Wilshram
Spokane	Pasco
Ephrata	Spokane
Wenatchee	Ephrata
Everett	Wenatchee
Everett	Edmonds
Mt_Vernon	Everett
Bellingham	Mt_Vernon
Vancouver	Bellingham

APPENDIX B: WESTERN U.S. RAILROAD NETWORKDEMAND MATRIX

	Albany	Anaheim	Antioch-Pit	Bakersfield	Barstow	Bellingham	Berkeley	Bingen-whi	Burbank
Albany	12130	-5	-18	-7	-78	-694	-16	-190	-16
Anaheim	-1995	243851	-362	-133	-1553	-13840	-319	-3783	-327
Antioch-Pittsburgh	-551	-28	67230	-37	-429	-3820	-88	-1044	-90
Bakersfield	-1501	-75	-273	183524	-1169	-10418	-240	-2848	-246
Barstow	-128	-6	-23	-9	15607	-891	-21	-244	-21
Bellingham	-14	-1	-3	-1	-11	1663	-2	-27	-2
Berkeley	-625	-31	-113	-42	-486	-4335	76312	-1185	-102
Bingen-white_Salmon	-53	-3	-10	-4	-41	-366	-8	6348	-9
Burbank	-610	-31	-111	-41	-475	-4233	-98	-1157	74507
Burbank_Airport	-610	-31	-111	-41	-475	-4233	-98	-1157	-100
Centrailia	-32	-2	-6	-2	-25	-224	-5	-61	-5
Chemult	-146	-7	-27	-10	-114	-1012	-23	-277	-24
Chico	-368	-18	-67	-25	-287	-2553	-59	-698	-60
Colfax	-9	0	-2	-1	-7	-64	-1	-18	-2
Corcoran	-127	-6	-23	-8	-99	-879	-20	-240	-21
Davis	-367	-18	-67	-24	-286	-2545	-59	-696	-60
Dunsmuir	-12	-1	-2	-1	-9	-81	-2	-22	-2
Edmonds	-161	-8	-29	-11	-126	-1120	-26	-306	-26
Ephrata	-5	0	-1	0	-4	-33	-1	-9	-1
Escondido	-813	-41	-148	-54	-633	-5640	-130	-1542	-133
Eugene	-56	-3	-10	-4	-43	-387	-9	-106	-9
Everett	-159	-8	-29	-11	-124	-1102	-25	-301	-26
Fresno	-2601	-130	-472	-173	-2025	-18044	-416	-4933	-426
Fullerton	-766	-38	-139	-51	-597	-5317	-123	-1453	-126
Gilroy	-252	-13	-46	-17	-196	-1750	-40	-478	-41
Glendale	-1186	-59	-215	-79	-923	-8227	-190	-2249	-194
Hanford	-254	-13	-46	-17	-197	-1759	-41	-481	-42
Hinkle	-38	-2	-7	-3	-30	-266	-6	-73	-6
Indio	-299	-15	-54	-20	-233	-2072	-48	-567	-49
Industry	-5	0	-1	0	-4	-33	-1	-9	-1
Irvine	-870	-44	-158	-58	-677	-6037	-139	-1650	-143
Kelso-Longview	-56	-3	-10	-4	-44	-389	-9	-106	-9
Klamath_Falls	-124	-6	-22	-8	-96	-857	-20	-234	-20
Los_Angeles	-22469	-1126	-4081	-1496	-17495	-155896	-3596	-42615	-3683
Madera	-263	-13	-48	-17	-205	-1823	-42	-498	-43
Martinez	-218	-11	-40	-15	-170	-1513	-35	-414	-36
Marysville	-75	-4	-14	-5	-58	-518	-12	-141	-12
Merced	-389	-19	-71	-26	-303	-2696	-62	-737	-64
Modesto	-1149	-58	-209	-76	-894	-7969	-184	-2178	-188
Moorpark_Simi_Valley	-191	-10	-35	-13	-149	-1326	-31	-362	-31
Mt_Vernon	-430	-22	-78	-29	-335	-2983	-69	-816	-70
Murrieta	-269	-14	-49	-18	-210	-1868	-43	-511	-44
Needles	-29	-1	-5	-2	-23	-204	-5	-56	-5
Norwalk	-634	-32	-115	-42	-494	-4402	-102	-1203	-104

	Albany	Anaheim	Antioch-Pit	Bakersfield	Barstow	Bellingham	Berkeley	Bingen-whi	Burbank
Oakland	-2430	-122	-441	-162	-1892	-16859	-389	-4609	-398
Oakland_Airport	-2430	-122	-441	-162	-1892	-16859	-389	-4609	-398
Oceanside	-979	-49	-178	-65	-763	-6795	-157	-1857	-161
Olympia-Lacey	-107	-5	-19	-7	-83	-743	-17	-203	-18
Oroville	-79	-4	-14	-5	-62	-549	-13	-150	-13
Palm_Springs	-260	-13	-47	-17	-203	-1806	-42	-494	-43
Palmdale_Airport	-709	-36	-129	-47	-552	-4923	-114	-1346	-116
Pasadena	-814	-41	-148	-54	-634	-5651	-130	-1545	-134
Pasco	-233	-12	-42	-16	-182	-1620	-37	-443	-38
Pomona	-909	-46	-165	-61	-708	-6307	-145	-1724	-149
Portland	-241	-12	-44	-16	-188	-1672	-39	-457	-39
Red_Bluff	-80	-4	-15	-5	-62	-555	-13	-152	-13
Redding	-492	-25	-89	-33	-383	-3412	-79	-933	-81
Redwood_City	-459	-23	-83	-31	-357	-3182	-73	-870	-75
Richmond	-603	-30	-110	-40	-470	-4186	-97	-1144	-99
Riverbank	-96	-5	-17	-6	-75	-668	-15	-183	-16
Riverside	-1552	-78	-282	-103	-1208	-10766	-248	-2943	-254
Roseville	-486	-24	-88	-32	-378	-3372	-78	-922	-80
Sacramento	-2475	-124	-450	-165	-1927	-17174	-396	-4695	-406
Salem	-208	-10	-38	-14	-162	-1445	-33	-395	-34
Salinas	-868	-43	-158	-58	-676	-6020	-139	-1646	-142
San_Fransisco	-4724	-237	-858	-315	-3678	-32774	-756	-8959	-774
San_Bernadido	-1127	-57	-205	-75	-878	-7822	-180	-2138	-185
San_Clemente	-304	-15	-55	-20	-236	-2107	-49	-576	-50
San_Diego	-7440	-373	-1351	-496	-5793	-51621	-1191	-14111	-1220
San_Jose	-5444	-273	-989	-363	-4239	-37769	-871	-10324	-892
San_Juan_Capistrano	-206	-10	-37	-14	-160	-1427	-33	-390	-34
San_Luis_Obispo	-269	-13	-49	-18	-209	-1864	-43	-510	-44
Santa_Ana	-2055	-103	-373	-137	-1600	-14261	-329	-3898	-337
Santa_Barbra	-545	-27	-99	-36	-424	-3781	-87	-1034	-89
Santa_Clarita	-919	-46	-167	-61	-716	-6377	-147	-1743	-151
Seattle	-343	-17	-62	-23	-267	-2377	-55	-650	-56
SFO_Airport	-4724	-237	-858	-315	-3678	-32774	-756	-8959	-774
Solana_Beach	-79	-4	-14	-5	-61	-548	-13	-150	-13
Sparks	-142	-7	-26	-9	-111	-987	-23	-270	-23
Spokane	-94	-5	-17	-6	-73	-651	-15	-178	-15
Stockton	-1482	-74	-269	-99	-1154	-10286	-237	-2812	-243
Suisun-Fairfield	-159	-8	-29	-11	-124	-1102	-25	-301	-26
Sylmar	-36	-2	-7	-2	-28	-251	-6	-69	-6
Tacoma	-68	-3	-12	-5	-53	-469	-11	-128	-11
Tahoe	-54	-3	-10	-4	-42	-372	-9	-102	-9
Truckee	-84	-4	-15	-6	-66	-585	-13	-160	-14
Turlock-Denair	-339	-17	-62	-23	-264	-2355	-54	-644	-56
Union_City	-407	-20	-74	-27	-317	-2821	-65	-771	-67
University_City	-407	-20	-74	-27	-317	-2821	-65	-771	-67
Van_Nuys	-416	-21	-76	-28	-324	-2886	-67	-789	-68
Vancouver	-539	-27	-98	-36	-420	-3740	-86	-1022	-88
Ventura	-712	-36	-129	-47	-555	-4943	-114	-1351	-117
Victorville	-389	-20	-71	-26	-303	-2702	-62	-739	-64
Wasco	-129	-6	-23	-9	-101	-897	-21	-245	-21
Wenatchee	-31	-2	-6	-2	-24	-214	-5	-59	-5
Wilshram	-138	-7	-25	-9	-108	-960	-22	-262	-23

	Gilroy	Glendale	Hanford	Hinkle	Indio	Industry	Irvine	Kelso-Long	Klamath_Fa	Los_Angele	Madera	Martinez
Albany	-40	-8	-39	-261	-33	-2116	-11	-178	-81	0	-38	-46
Anaheim	-791	-168	-787	-5198	-668	-42215	-229	-3553	-1614	-9	-759	-915
Antioch-Pittsburgh	-218	-46	-217	-1435	-184	-11651	-63	-981	-446	-2	-210	-252
Bakersfield	-595	-127	-592	-3913	-503	-31776	-173	-2675	-1215	-7	-571	-688
Barstow	-51	-11	-51	-335	-43	-2718	-15	-229	-104	-1	-49	-59
Bellingham	-6	-1	-6	-38	-5	-305	-2	-26	-12	0	-5	-7
Berkeley	-248	-53	-246	-1628	-209	-13223	-72	-1113	-506	-3	-238	-286
Bingen-white_Salmon	-21	-4	-21	-137	-18	-1116	-6	-94	-43	0	-20	-24
Burbank	-242	-51	-241	-1590	-204	-12911	-70	-1087	-494	-3	-232	-280
Burbank_Airport	-242	-51	-241	-1590	-204	-12911	-70	-1087	-494	-3	-232	-280
Centrailia	-13	-3	-13	-84	-11	-685	-4	-58	-26	0	-12	-15
Chemult	-58	-12	-58	-380	-49	-3088	-17	-260	-118	-1	-56	-67
Chico	-146	-31	-145	-959	-123	-7788	-42	-656	-298	-2	-140	-169
Colfax	-4	-1	-4	-24	-3	-196	-1	-16	-7	0	-4	-4
Corcoran	-50	-11	-50	-330	-42	-2682	-15	-226	-103	-1	-48	-58
Davis	-145	-31	-145	-956	-123	-7762	-42	-653	-297	-2	-140	-168
Dunsmuir	-5	-1	-5	-30	-4	-247	-1	-21	-9	0	-4	-5
Edmonds	-64	-14	-64	-421	-54	-3415	-19	-287	-131	-1	-61	-74
Ephrata	-2	0	-2	-12	-2	-101	-1	-8	-4	0	-2	-2
Escondido	-322	-69	-321	-2118	-272	-17202	-93	-1448	-658	-4	-309	-373
Eugene	-22	-5	-22	-145	-19	-1180	-6	-99	-45	0	-21	-26
Everett	-63	-13	-63	-414	-53	-3363	-18	-283	-129	-1	-60	-73
Fresno	-1031	-219	-1026	-6777	-871	-55039	-299	-4633	-2105	-12	-990	-1192
Fullerton	-304	-65	-302	-1997	-257	-16217	-88	-1365	-620	-3	-292	-351
Gilroy	30738	-21	-99	-657	-84	-5336	-29	-449	-204	-1	-96	-116
Glendale	-470	144905	-468	-3090	-397	-25093	-136	-2112	-960	-5	-451	-544
Hanford	-101	-21	30903	-661	-85	-5365	-29	-452	-205	-1	-96	-116
Hinkle	-15	-3	-15	4593	-13	-812	-4	-68	-31	0	-15	-18
Indio	-118	-25	-118	-778	36429	-6321	-34	-532	-242	-1	-114	-137
Industry	-2	0	-2	-12	-2	478	-1	-8	-4	0	-2	-2
Irvine	-345	-73	-343	-2267	-291	-18413	106306	-1550	-704	-4	-331	-399
Kelso-Longview	-22	-5	-22	-146	-19	-1188	-6	6765	-45	0	-21	-26
Klamath_Falls	-49	-10	-49	-322	-41	-2615	-14	-220	15011	-1	-47	-57
Los_Angeles	-8911	-1895	-8863	-58554	-7522	-475514	-2582	-40025	-18185	2747754	-8552	-10302
Madera	-104	-22	-104	-685	-88	-5560	-30	-468	-213	-1	32032	-120
Martinez	-86	-18	-86	-568	-73	-4616	-25	-389	-177	-1	-83	26574
Marysville	-30	-6	-29	-194	-25	-1579	-9	-133	-60	0	-28	-34
Merced	-154	-33	-153	-1013	-130	-8223	-45	-692	-314	-2	-148	-178
Modesto	-455	-97	-453	-2993	-385	-24306	-132	-2046	-930	-5	-437	-527
Moorpark_Simi_Valley	-76	-16	-75	-498	-64	-4043	-22	-340	-155	-1	-73	-88
Mt_Vernon	-171	-36	-170	-1121	-144	-9100	-49	-766	-348	-2	-164	-197
Murrieta	-107	-23	-106	-702	-90	-5699	-31	-480	-218	-1	-102	-123
Needles	-12	-2	-12	-77	-10	-622	-3	-52	-24	0	-11	-13
Norwalk	-252	-54	-250	-1653	-212	-13426	-73	-1130	-513	-3	-241	-291

	Gilroy	Glendale	Hanford	Hinkle	Indio	Industry	Irvine	Kelso-Long	Klamath_Fa	Los_Angele	Madera	Martinez
Oakland	-964	-205	-958	-6332	-814	-51424	-279	-4329	-1967	-11	-925	-1114
Oakland_Airport	-964	-205	-958	-6332	-814	-51424	-279	-4329	-1967	-11	-925	-1114
Oceanside	-388	-83	-386	-2552	-328	-20726	-113	-1745	-793	-4	-373	-449
Olympia-Lacey	-42	-9	-42	-279	-36	-2265	-12	-191	-87	0	-41	-49
Oroville	-31	-7	-31	-206	-26	-1674	-9	-141	-64	0	-30	-36
Palm_Springs	-103	-22	-103	-678	-87	-5509	-30	-464	-211	-1	-99	-119
Palmdale_Airport	-281	-60	-280	-1849	-238	-15015	-82	-1264	-574	-3	-270	-325
Pasadena	-323	-69	-321	-2123	-273	-17238	-94	-1451	-659	-4	-310	-373
Pasco	-93	-20	-92	-608	-78	-4941	-27	-416	-189	-1	-89	-107
Pomona	-360	-77	-359	-2369	-304	-19237	-104	-1619	-736	-4	-346	-417
Portland	-96	-20	-95	-628	-81	-5098	-28	-429	-195	-1	-92	-110
Red_Bluff	-32	-7	-32	-208	-27	-1692	-9	-142	-65	0	-30	-37
Redding	-195	-41	-194	-1282	-165	-10407	-57	-876	-398	-2	-187	-225
Redwood_City	-182	-39	-181	-1195	-154	-9704	-53	-817	-371	-2	-175	-210
Richmond	-239	-51	-238	-1572	-202	-12769	-69	-1075	-488	-3	-230	-277
Riverbank	-38	-8	-38	-251	-32	-2037	-11	-171	-78	0	-37	-44
Riverside	-615	-131	-612	-4044	-520	-32840	-178	-2764	-1256	-7	-591	-711
Roseville	-193	-41	-192	-1267	-163	-10286	-56	-866	-393	-2	-185	-223
Sacramento	-982	-209	-976	-6450	-829	-52383	-284	-4409	-2003	-11	-942	-1135
Salem	-83	-18	-82	-543	-70	-4407	-24	-371	-169	-1	-79	-95
Salinas	-344	-73	-342	-2261	-291	-18364	-100	-1546	-702	-4	-330	-398
San_Fransisco	-1873	-398	-1863	-12310	-1581	-99966	-543	-8414	-3823	-21	-1798	-2166
San_Bernadido	-447	-95	-445	-2938	-377	-23859	-130	-2008	-912	-5	-429	-517
San_Clemente	-120	-26	-120	-791	-102	-6427	-35	-541	-246	-1	-116	-139
San_Diego	-2951	-627	-2935	-19389	-2491	-157454	-855	-13253	-6021	-33	-2832	-3411
San_Jose	-2159	-459	-2147	-14186	-1822	-115203	-626	-9697	-4406	-24	-2072	-2496
San_Juan_Capistrano	-82	-17	-81	-536	-69	-4353	-24	-366	-166	-1	-78	-94
San_Luis_Obispo	-107	-23	-106	-700	-90	-5686	-31	-479	-217	-1	-102	-123
Santa_Ana	-815	-173	-811	-5356	-688	-43498	-236	-3661	-1663	-9	-782	-942
Santa_Barbra	-216	-46	-215	-1420	-182	-11532	-63	-971	-441	-2	-207	-250
Santa_Clarita	-364	-78	-363	-2395	-308	-19451	-106	-1637	-744	-4	-350	-421
Seattle	-136	-29	-135	-893	-115	-7251	-39	-610	-277	-2	-130	-157
SFO_Airport	-1873	-398	-1863	-12310	-1581	-99966	-543	-8414	-3823	-21	-1798	-2166
Solana_Beach	-31	-7	-31	-206	-26	-1670	-9	-141	-64	0	-30	-36
Sparks	-56	-12	-56	-371	-48	-3012	-16	-253	-115	-1	-54	-65
Spokane	-37	-8	-37	-245	-31	-1986	-11	-167	-76	0	-36	-43
Stockton	-588	-125	-585	-3863	-496	-31373	-170	-2641	-1200	-7	-564	-680
Suisun-Fairfield	-63	-13	-63	-414	-53	-3361	-18	-283	-129	-1	-60	-73
Sylmar	-14	-3	-14	-94	-12	-766	-4	-64	-29	0	-14	-17
Tacoma	-27	-6	-27	-176	-23	-1432	-8	-121	-55	0	-26	-31
Tahoe	-21	-5	-21	-140	-18	-1134	-6	-95	-43	0	-20	-25
Truckee	-33	-7	-33	-220	-28	-1784	-10	-150	-68	0	-32	-39
Turlock-Denair	-135	-29	-134	-884	-114	-7183	-39	-605	-275	-2	-129	-156
Union_City	-161	-34	-160	-1060	-136	-8606	-47	-724	-329	-2	-155	-186
University_City	-161	-34	-160	-1060	-136	-8606	-47	-724	-329	-2	-155	-186
Van_Nuys	-165	-35	-164	-1084	-139	-8802	-48	-741	-337	-2	-158	-191
Vancouver	-214	-45	-213	-1405	-180	-11408	-62	-960	-436	-2	-205	-247
Ventura	-283	-60	-281	-1857	-239	-15077	-82	-1269	-577	-3	-271	-327
Victorville	-154	-33	-154	-1015	-130	-8241	-45	-694	-315	-2	-148	-179
Wasco	-51	-11	-51	-337	-43	-2737	-15	-230	-105	-1	-49	-59
Wenatchee	-12	-3	-12	-80	-10	-653	-4	-55	-25	0	-12	-14
Wilshram	-55	-12	-55	-360	-46	-2927	-16	-246	-112	-1	-53	-63

	Marysville	Merced	Modesto	Moorpark_	Mt_Vernon	Murrieta	Needles	Norwalk	Oakland	Oakland_A	Oceanside	Olympia-La
Albany	-134	-26	-9	-52	-23	-37	-340	-16	-4	-4	-10	-93
Anaheim	-2674	-513	-174	-1044	-464	-741	-6791	-314	-82	-82	-204	-1864
Antioch-Pittsburgh	-738	-142	-48	-288	-128	-204	-1874	-87	-23	-23	-56	-514
Bakersfield	-2013	-386	-131	-786	-349	-558	-5112	-237	-62	-62	-153	-1403
Barstow	-172	-33	-11	-67	-30	-48	-437	-20	-5	-5	-13	-120
Bellingham	-19	-4	-1	-8	-3	-5	-49	-2	-1	-1	-1	-13
Berkeley	-837	-161	-54	-327	-145	-232	-2127	-98	-26	-26	-64	-584
Bingen-white_Salmon	-71	-14	-5	-28	-12	-20	-180	-8	-2	-2	-5	-49
Burbank	-818	-157	-53	-319	-142	-227	-2077	-96	-25	-25	-62	-570
Burbank_Airport	-818	-157	-53	-319	-142	-227	-2077	-96	-25	-25	-62	-570
Centrailia	-43	-8	-3	-17	-8	-12	-110	-5	-1	-1	-3	-30
Chemult	-196	-38	-13	-76	-34	-54	-497	-23	-6	-6	-15	-136
Chico	-493	-95	-32	-193	-86	-137	-1253	-58	-15	-15	-38	-344
Colfax	-12	-2	-1	-5	-2	-3	-31	-1	0	0	-1	-9
Corcoran	-170	-33	-11	-66	-29	-47	-432	-20	-5	-5	-13	-118
Davis	-492	-94	-32	-192	-85	-136	-1249	-58	-15	-15	-37	-343
Dunsmuir	-16	-3	-1	-6	-3	-4	-40	-2	0	0	-1	-11
Edmonds	-216	-42	-14	-84	-38	-60	-549	-25	-7	-7	-16	-151
Ephrata	-6	-1	0	-2	-1	-2	-16	-1	0	0	0	-4
Escondido	-1090	-209	-71	-425	-189	-302	-2767	-128	-33	-33	-83	-759
Eugene	-75	-14	-5	-29	-13	-21	-190	-9	-2	-2	-6	-52
Everett	-213	-41	-14	-83	-37	-59	-541	-25	-7	-7	-16	-148
Fresno	-3486	-669	-226	-1361	-605	-966	-8854	-410	-107	-107	-266	-2430
Fullerton	-1027	-197	-67	-401	-178	-285	-2609	-121	-32	-32	-78	-716
Gilroy	-338	-65	-22	-132	-59	-94	-858	-40	-10	-10	-26	-236
Glendale	-1589	-305	-103	-621	-276	-440	-4037	-187	-49	-49	-121	-1108
Hanford	-340	-65	-22	-133	-59	-94	-863	-40	-10	-10	-26	-237
Hinkle	-51	-10	-3	-20	-9	-14	-131	-6	-2	-2	-4	-36
Indio	-400	-77	-26	-156	-69	-111	-1017	-47	-12	-12	-30	-279
Industry	-6	-1	0	-2	-1	-2	-16	-1	0	0	0	-4
Irvine	-1166	-224	-76	-455	-202	-323	-2962	-137	-36	-36	-89	-813
Kelso-Longview	-75	-14	-5	-29	-13	-21	-191	-9	-2	-2	-6	-52
Klamath_Falls	-166	-32	-11	-65	-29	-46	-421	-19	-5	-5	-13	-115
Los_Angeles	-30117	-5783	-1956	-11761	-5225	-8344	-76496	-3542	-925	-925	-2294	-20994
Madera	-352	-68	-23	-138	-61	-98	-895	-41	-11	-11	-27	-245
Martinez	-292	-56	-19	-114	-51	-81	-743	-34	-9	-9	-22	-204
Marysville	9024	-19	-6	-39	-17	-28	-254	-12	-3	-3	-8	-70
Merced	-521	47419	-34	-203	-90	-144	-1323	-61	-16	-16	-40	-363
Modesto	-1539	-296	140360	-601	-267	-426	-3910	-181	-47	-47	-117	-1073
Moorpark_Simi_Valley	-256	-49	-17	23264	-44	-71	-650	-30	-8	-8	-20	-179
Mt_Vernon	-576	-111	-37	-225	52487	-160	-1464	-68	-18	-18	-44	-402
Murrieta	-361	-69	-23	-141	-63	32833	-917	-42	-11	-11	-27	-252
Needles	-39	-8	-3	-15	-7	-11	3492	-5	-1	-1	-3	-27
Norwalk	-850	-163	-55	-332	-148	-236	-2160	77487	-26	-26	-65	-593

	Marysville	Merced	Modesto	Moorpark_	Mt_Vernon	Murrieta	Needles	Norwalk	Oakland	Oakland_A	Oceanside	Olympia-La
Oakland	-3257	-625	-212	-1272	-565	-902	-8273	-383	297065	-100	-248	-2270
Oakland_Airport	-3257	-625	-212	-1272	-565	-902	-8273	-383	-100	297065	-248	-2270
Oceanside	-1313	-252	-85	-513	-228	-364	-3334	-154	-40	-40	119668	-915
Olympia-Lacey	-143	-28	-9	-56	-25	-40	-364	-17	-4	-4	-11	12989
Oroville	-106	-20	-7	-41	-18	-29	-269	-12	-3	-3	-8	-74
Palm_Springs	-349	-67	-23	-136	-61	-97	-886	-41	-11	-11	-27	-243
Palmdale_Airport	-951	-183	-62	-371	-165	-263	-2416	-112	-29	-29	-72	-663
Pasadena	-1092	-210	-71	-426	-189	-302	-2773	-128	-34	-34	-83	-761
Pasco	-313	-60	-20	-122	-54	-87	-795	-37	-10	-10	-24	-218
Pomona	-1218	-234	-79	-476	-211	-338	-3095	-143	-37	-37	-93	-849
Portland	-323	-62	-21	-126	-56	-89	-820	-38	-10	-10	-25	-225
Red_Bluff	-107	-21	-7	-42	-19	-30	-272	-13	-3	-3	-8	-75
Redding	-659	-127	-43	-257	-114	-183	-1674	-78	-20	-20	-50	-459
Redwood_City	-615	-118	-40	-240	-107	-170	-1561	-72	-19	-19	-47	-428
Richmond	-809	-155	-53	-316	-140	-224	-2054	-95	-25	-25	-62	-564
Riverbank	-129	-25	-8	-50	-22	-36	-328	-15	-4	-4	-10	-90
Riverside	-2080	-399	-135	-812	-361	-576	-5283	-245	-64	-64	-158	-1450
Roseville	-651	-125	-42	-254	-113	-180	-1655	-77	-20	-20	-50	-454
Sacramento	-3318	-637	-216	-1296	-576	-919	-8427	-390	-102	-102	-253	-2313
Salem	-279	-54	-18	-109	-48	-77	-709	-33	-9	-9	-21	-195
Salinas	-1163	-223	-76	-454	-202	-322	-2954	-137	-36	-36	-89	-811
San_Fransisco	-6331	-1216	-411	-2472	-1099	-1754	-16081	-745	-194	-194	-482	-4414
San_Bernadido	-1511	-290	-98	-590	-262	-419	-3838	-178	-46	-46	-115	-1053
San_Clemente	-407	-78	-26	-159	-71	-113	-1034	-48	-12	-12	-31	-284
San_Diego	-9972	-1915	-648	-3894	-1730	-2763	-25330	-1173	-306	-306	-760	-6952
San_Jose	-7296	-1401	-474	-2849	-1266	-2021	-18533	-858	-224	-224	-556	-5086
San_Juan_Capistrano	-276	-53	-18	-108	-48	-76	-700	-32	-8	-8	-21	-192
San_Luis_Obispo	-360	-69	-23	-141	-62	-100	-915	-42	-11	-11	-27	-251
Santa_Ana	-2755	-529	-179	-1076	-478	-763	-6997	-324	-85	-85	-210	-1920
Santa_Barbra	-730	-140	-47	-285	-127	-202	-1855	-86	-22	-22	-56	-509
Santa_Clarita	-1232	-237	-80	-481	-214	-341	-3129	-145	-38	-38	-94	-859
Seattle	-459	-88	-30	-179	-80	-127	-1167	-54	-14	-14	-35	-320
SFO_Airport	-6331	-1216	-411	-2472	-1099	-1754	-16081	-745	-194	-194	-482	-4414
Solana_Beach	-106	-20	-7	-41	-18	-29	-269	-12	-3	-3	-8	-74
Sparks	-191	-37	-12	-74	-33	-53	-484	-22	-6	-6	-15	-133
Spokane	-126	-24	-8	-49	-22	-35	-320	-15	-4	-4	-10	-88
Stockton	-1987	-382	-129	-776	-345	-550	-5047	-234	-61	-61	-151	-1385
Suisun-Fairfield	-213	-41	-14	-83	-37	-59	-541	-25	-7	-7	-16	-148
Sylmar	-49	-9	-3	-19	-8	-13	-123	-6	-1	-1	-4	-34
Tacoma	-91	-17	-6	-35	-16	-25	-230	-11	-3	-3	-7	-63
Tahoe	-72	-14	-5	-28	-12	-20	-182	-8	-2	-2	-5	-50
Truckee	-113	-22	-7	-44	-20	-31	-287	-13	-3	-3	-9	-79
Turlock-Denair	-455	-87	-30	-178	-79	-126	-1156	-53	-14	-14	-35	-317
Union_City	-545	-105	-35	-213	-95	-151	-1384	-64	-17	-17	-42	-380
University_City	-545	-105	-35	-213	-95	-151	-1384	-64	-17	-17	-42	-380
Van_Nuys	-557	-107	-36	-218	-97	-154	-1416	-66	-17	-17	-42	-389
Vancouver	-723	-139	-47	-282	-125	-200	-1835	-85	-22	-22	-55	-504
Ventura	-955	-183	-62	-373	-166	-265	-2425	-112	-29	-29	-73	-666
Victorville	-522	-100	-34	-204	-91	-145	-1326	-61	-16	-16	-40	-364
Wasco	-173	-33	-11	-68	-30	-48	-440	-20	-5	-5	-13	-121
Wenatchee	-41	-8	-3	-16	-7	-11	-105	-5	-1	-1	-3	-29
Wilshram	-185	-36	-12	-72	-32	-51	-471	-22	-6	-6	-14	-129

cey	Oroville	Palm_Sprir	Palmdale_/	Pasadena	Pasco	Pomona	Portland	Red_Bluff	Redding	Redwood_(	Richmond	Riverbank
Albany	-126	-38	-14	-12	-43	-11	-42	-125	-20	-22	-17	-104
Anaheim	-2522	-766	-281	-245	-854	-219	-828	-2495	-406	-435	-331	-2073
Antioch-Pittsburgh	-696	-211	-78	-68	-236	-61	-229	-689	-112	-120	-91	-572
Bakersfield	-1899	-577	-212	-184	-643	-165	-623	-1878	-305	-327	-249	-1560
Barstow	-162	-49	-18	-16	-55	-14	-53	-161	-26	-28	-21	-133
Bellingham	-18	-6	-2	-2	-6	-2	-6	-18	-3	-3	-2	-15
Berkeley	-790	-240	-88	-77	-268	-69	-259	-781	-127	-136	-104	-649
Bingen-white_Salmon	-67	-20	-7	-6	-23	-6	-22	-66	-11	-11	-9	-55
Burbank	-771	-234	-86	-75	-261	-67	-253	-763	-124	-133	-101	-634
Burbank_Airport	-771	-234	-86	-75	-261	-67	-253	-763	-124	-133	-101	-634
Centrailia	-41	-12	-5	-4	-14	-4	-13	-40	-7	-7	-5	-34
Chemult	-185	-56	-21	-18	-62	-16	-61	-182	-30	-32	-24	-152
Chico	-465	-141	-52	-45	-158	-40	-153	-460	-75	-80	-61	-382
Colfax	-12	-4	-1	-1	-4	-1	-4	-12	-2	-2	-2	-10
Corcoran	-160	-49	-18	-16	-54	-14	-53	-159	-26	-28	-21	-132
Davis	-464	-141	-52	-45	-157	-40	-152	-459	-75	-80	-61	-381
Dunsmuir	-15	-4	-2	-1	-5	-1	-5	-15	-2	-3	-2	-12
Edmonds	-204	-62	-23	-20	-69	-18	-67	-202	-33	-35	-27	-168
Ephrata	-6	-2	-1	-1	-2	-1	-2	-6	-1	-1	-1	-5
Escondido	-1028	-312	-115	-100	-348	-89	-337	-1017	-165	-177	-135	-845
Eugene	-71	-21	-8	-7	-24	-6	-23	-70	-11	-12	-9	-58
Everett	-201	-61	-22	-20	-68	-17	-66	-199	-32	-35	-26	-165
Fresno	-3289	-999	-367	-319	-1114	-286	-1080	-3253	-529	-567	-431	-2702
Fullerton	-969	-294	-108	-94	-328	-84	-318	-958	-156	-167	-127	-796
Gilroy	-319	-97	-36	-31	-108	-28	-105	-315	-51	-55	-42	-262
Glendale	-1499	-455	-167	-146	-508	-130	-492	-1483	-241	-259	-197	-1232
Hanford	-321	-97	-36	-31	-109	-28	-105	-317	-52	-55	-42	-263
Hinkle	-49	-15	-5	-5	-16	-4	-16	-48	-8	-8	-6	-40
Indio	-378	-115	-42	-37	-128	-33	-124	-374	-61	-65	-50	-310
Industry	-6	-2	-1	-1	-2	-1	-2	-6	-1	-1	-1	-5
Irvine	-1100	-334	-123	-107	-373	-96	-361	-1088	-177	-190	-144	-904
Kelso-Longview	-71	-22	-8	-7	-24	-6	-23	-70	-11	-12	-9	-58
Klamath_Falls	-156	-47	-17	-15	-53	-14	-51	-155	-25	-27	-20	-128
Los_Angeles	-28412	-8632	-3167	-2759	-9624	-2472	-9327	-28103	-4569	-4900	-3724	-23346
Madera	-332	-101	-37	-32	-113	-29	-109	-329	-53	-57	-44	-273
Martinez	-276	-84	-31	-27	-93	-24	-91	-273	-44	-48	-36	-227
Marysville	-94	-29	-11	-9	-32	-8	-31	-93	-15	-16	-12	-78
Merced	-491	-149	-55	-48	-166	-43	-161	-486	-79	-85	-64	-404
Modesto	-1452	-441	-162	-141	-492	-126	-477	-1437	-234	-250	-190	-1193
Moorpark_Simi_Valley	-242	-73	-27	-23	-82	-21	-79	-239	-39	-42	-32	-199
Mt_Vernon	-544	-165	-61	-53	-184	-47	-178	-538	-87	-94	-71	-447
Murrieta	-341	-103	-38	-33	-115	-30	-112	-337	-55	-59	-45	-280
Needles	-37	-11	-4	-4	-13	-3	-12	-37	-6	-6	-5	-31
Norwalk	-802	-244	-89	-78	-272	-70	-263	-794	-129	-138	-105	-659

cey	Oroville	Palm_Sprin	Palmdale_A	Pasadena	Pasco	Pomona	Portland	Red_Bluff	Redding	Redwood_C	Richmond	Riverbank
Oakland	-3073	-933	-342	-298	-1041	-267	-1009	-3039	-494	-530	-403	-2525
Oakland_Airport	-3073	-933	-342	-298	-1041	-267	-1009	-3039	-494	-530	-403	-2525
Oceanside	-1238	-376	-138	-120	-419	-108	-407	-1225	-199	-214	-162	-1018
Olympia-Lacey	-135	-41	-15	-13	-46	-12	-44	-134	-22	-23	-18	-111
Oroville	9571	-30	-11	-10	-34	-9	-33	-99	-16	-17	-13	-82
Palm_Springs	-329	31735	-37	-32	-111	-29	-108	-326	-53	-57	-43	-270
Palmdale_Airport	-897	-273	86670	-87	-304	-78	-295	-887	-144	-155	-118	-737
Pasadena	-1030	-313	-115	99511	-349	-90	-338	-1019	-166	-178	-135	-846
Pasco	-295	-90	-33	-29	28453	-26	-97	-292	-47	-51	-39	-243
Pomona	-1149	-349	-128	-112	-389	111066	-377	-1137	-185	-198	-151	-944
Portland	-305	-93	-34	-30	-103	-27	29362	-301	-49	-53	-40	-250
Red_Bluff	-101	-31	-11	-10	-34	-9	-33	9678	-16	-17	-13	-83
Redding	-622	-189	-69	-60	-211	-54	-204	-615	60041	-107	-82	-511
Redwood_City	-580	-176	-65	-56	-196	-50	-190	-574	-93	55978	-76	-476
Richmond	-763	-232	-85	-74	-258	-66	-250	-755	-123	-132	73689	-627
Riverbank	-122	-37	-14	-12	-41	-11	-40	-120	-20	-21	-16	11670
Riverside	-1962	-596	-219	-191	-665	-171	-644	-1941	-316	-338	-257	-1612
Roseville	-615	-187	-69	-60	-208	-53	-202	-608	-99	-106	-81	-505
Sacramento	-3130	-951	-349	-304	-1060	-272	-1027	-3096	-503	-540	-410	-2572
Salem	-263	-80	-29	-26	-89	-23	-86	-260	-42	-45	-35	-216
Salinas	-1097	-333	-122	-107	-372	-95	-360	-1085	-176	-189	-144	-902
San_Fransisco	-5973	-1815	-666	-580	-2023	-520	-1961	-5908	-961	-1030	-783	-4908
San_Bernadido	-1426	-433	-159	-138	-483	-124	-468	-1410	-229	-246	-187	-1171
San_Clemente	-384	-117	-43	-37	-130	-33	-126	-380	-62	-66	-50	-316
San_Diego	-9408	-2858	-1049	-913	-3187	-818	-3088	-9306	-1513	-1623	-1233	-7730
San_Jose	-6884	-2091	-767	-668	-2332	-599	-2260	-6809	-1107	-1187	-902	-5656
San_Juan_Capistrano	-260	-79	-29	-25	-88	-23	-85	-257	-42	-45	-34	-214
San_Luis_Obispo	-340	-103	-38	-33	-115	-30	-112	-336	-55	-59	-45	-279
Santa_Ana	-2599	-790	-290	-252	-880	-226	-853	-2571	-418	-448	-341	-2136
Santa_Barbra	-689	-209	-77	-67	-233	-60	-226	-682	-111	-119	-90	-566
Santa_Clarita	-1162	-353	-130	-113	-394	-101	-381	-1150	-187	-200	-152	-955
Seattle	-433	-132	-48	-42	-147	-38	-142	-429	-70	-75	-57	-356
SFO_Airport	-5973	-1815	-666	-580	-2023	-520	-1961	-5908	-961	-1030	-783	-4908
Solana_Beach	-100	-30	-11	-10	-34	-9	-33	-99	-16	-17	-13	-82
Sparks	-180	-55	-20	-17	-61	-16	-59	-178	-29	-31	-24	-148
Spokane	-119	-36	-13	-12	-40	-10	-39	-117	-19	-20	-16	-98
Stockton	-1875	-569	-209	-182	-635	-163	-615	-1854	-301	-323	-246	-1540
Suisun-Fairfield	-201	-61	-22	-20	-68	-17	-66	-199	-32	-35	-26	-165
Sylmar	-46	-14	-5	-4	-15	-4	-15	-45	-7	-8	-6	-38
Tacoma	-86	-26	-10	-8	-29	-7	-28	-85	-14	-15	-11	-70
Tahoe	-68	-21	-8	-7	-23	-6	-22	-67	-11	-12	-9	-56
Truckee	-107	-32	-12	-10	-36	-9	-35	-105	-17	-18	-14	-88
Turlock-Denair	-429	-130	-48	-42	-145	-37	-141	-425	-69	-74	-56	-353
Union_City	-514	-156	-57	-50	-174	-45	-169	-509	-83	-89	-67	-423
University_City	-514	-156	-57	-50	-174	-45	-169	-509	-83	-89	-67	-423
Van_Nuys	-526	-160	-59	-51	-178	-46	-173	-520	-85	-91	-69	-432
Vancouver	-682	-207	-76	-66	-231	-59	-224	-674	-110	-118	-89	-560
Ventura	-901	-274	-100	-87	-305	-78	-296	-891	-145	-155	-118	-740
Victorville	-492	-150	-55	-48	-167	-43	-162	-487	-79	-85	-65	-405
Wasco	-164	-50	-18	-16	-55	-14	-54	-162	-26	-28	-21	-134
Wenatchee	-39	-12	-4	-4	-13	-3	-13	-39	-6	-7	-5	-32
Wilshram	-175	-53	-19	-17	-59	-15	-57	-173	-28	-30	-23	-144

	Riverside	Roseville	Sacrament	Salem	Salinas	San_Fransi	San_Bernad	San_Clemer	San_Diego	San_Jose	San_Juan_(	San_Luis_C	Santa_Ana	Santa_Barb	Santa_Clar	Seattle	SFO_Airpor	Solana_Bea
Albany	-6	-21	-4	-48	-12	-2	-9	-33	-1	-2	-49	-37	-5	-18	-11	-29	-2	-127
Anaheim	-129	-410	-81	-958	-230	-42	-177	-657	-27	-37	-970	-742	-97	-366	-217	-582	-42	-2527
Antioch-Pittsburgh	-35	-113	-22	-264	-63	-12	-49	-181	-7	-10	-268	-205	-27	-101	-60	-161	-12	-698
Bakersfield	-97	-309	-61	-721	-173	-32	-133	-494	-20	-28	-730	-559	-73	-276	-163	-438	-32	-1902
Barstow	-8	-26	-5	-62	-15	-3	-11	-42	-2	-2	-62	-48	-6	-24	-14	-37	-3	-163
Bellingham	-1	-3	-1	-7	-2	0	-1	-5	0	0	-7	-5	-1	-3	-2	-4	0	-18
Berkeley	-40	-129	-25	-300	-72	-13	-55	-206	-8	-11	-304	-233	-30	-115	-68	-182	-13	-792
Bingen-white_Salmon	-3	-11	-2	-25	-6	-1	-5	-17	-1	-1	-26	-20	-3	-10	-6	-15	-1	-67
Burbank	-39	-126	-25	-293	-70	-13	-54	-201	-8	-11	-297	-227	-30	-112	-66	-178	-13	-773
Burbank_Airport	-39	-126	-25	-293	-70	-13	-54	-201	-8	-11	-297	-227	-30	-112	-66	-178	-13	-773
Centrailia	-2	-7	-1	-16	-4	-1	-3	-11	0	-1	-16	-12	-2	-6	-4	-9	-1	-41
Chemult	-9	-30	-6	-70	-17	-3	-13	-48	-2	-3	-71	-54	-7	-27	-16	-43	-3	-185
Chico	-24	-76	-15	-177	-42	-8	-33	-121	-5	-7	-179	-137	-18	-68	-40	-107	-8	-466
Colfax	-1	-2	0	-4	-1	0	-1	-3	0	0	-4	-3	0	-2	-1	-3	0	-12
Corcoran	-8	-26	-5	-61	-15	-3	-11	-42	-2	-2	-62	-47	-6	-23	-14	-37	-3	-161
Davis	-24	-75	-15	-176	-42	-8	-33	-121	-5	-7	-178	-137	-18	-67	-40	-107	-8	-465
Dunsmuir	-1	-2	0	-6	-1	0	-1	-4	0	0	-6	-4	-1	-2	-1	-3	0	-15
Edmonds	-10	-33	-7	-77	-19	-3	-14	-53	-2	-3	-78	-60	-8	-30	-18	-47	-3	-204
Ephrata	0	-1	0	-2	-1	0	0	-2	0	0	-2	-2	0	-1	-1	-1	0	-6
Escondido	-52	-167	-33	-390	-94	-17	-72	-268	-11	-15	-395	-303	-40	-149	-88	-237	-17	-1030
Eugene	-4	-11	-2	-27	-6	-1	-5	-18	-1	-1	-27	-21	-3	-10	-6	-16	-1	-71
Everett	-10	-33	-6	-76	-18	-3	-14	-52	-2	-3	-77	-59	-8	-29	-17	-46	-3	-201
Fresno	-168	-535	-105	-1249	-300	-55	-231	-856	-35	-48	-1264	-968	-127	-477	-283	-759	-55	-3295
Fullerton	-49	-158	-31	-368	-88	-16	-68	-252	-10	-14	-373	-285	-37	-141	-83	-224	-16	-971
Gilroy	-16	-52	-10	-121	-29	-5	-22	-83	-3	-5	-123	-94	-12	-46	-27	-74	-5	-319
Glendale	-76	-244	-48	-569	-137	-25	-105	-390	-16	-22	-576	-441	-58	-218	-129	-346	-25	-1502
Hanford	-16	-52	-10	-122	-29	-5	-22	-83	-3	-5	-123	-94	-12	-47	-28	-74	-5	-321
Hinkle	-2	-8	-2	-18	-4	-1	-3	-13	-1	-1	-19	-14	-2	-7	-4	-11	-1	-49
Indio	-19	-61	-12	-143	-34	-6	-26	-98	-4	-5	-145	-111	-15	-55	-32	-87	-6	-378
Industry	0	-1	0	-2	-1	0	0	-2	0	0	-2	-2	0	-1	-1	-1	0	-6
Irvine	-56	-179	-35	-418	-100	-18	-77	-287	-12	-16	-423	-324	-42	-160	-95	-254	-18	-1102
Kelso-Longview	-4	-12	-2	-27	-6	-1	-5	-18	-1	-1	-27	-21	-3	-10	-6	-16	-1	-71
Klamath_Falls	-8	-25	-5	-59	-14	-3	-11	-41	-2	-2	-60	-46	-6	-23	-13	-36	-3	-157
Los_Angeles	-1448	-4623	-908	-10791	-2589	-476	-1993	-7399	-302	-413	-10923	-8363	-1093	-4123	-2445	-6558	-476	-28467
Madera	-17	-54	-11	-126	-30	-6	-23	-87	-4	-5	-128	-98	-13	-48	-29	-77	-6	-333
Martinez	-14	-45	-9	-105	-25	-5	-19	-72	-3	-4	-106	-81	-11	-40	-24	-64	-5	-276
Marysville	-5	-15	-3	-36	-9	-2	-7	-25	-1	-1	-36	-28	-4	-14	-8	-22	-2	-95
Merced	-25	-80	-16	-187	-45	-8	-34	-128	-5	-7	-189	-145	-19	-71	-42	-113	-8	-492
Modesto	-74	-236	-46	-552	-132	-24	-102	-378	-15	-21	-558	-427	-56	-211	-125	-335	-24	-1455
Moorpark_Simi_Valley	-12	-39	-8	-92	-22	-4	-17	-63	-3	-4	-93	-71	-9	-35	-21	-56	-4	-242
Mt_Vernon	-28	-88	-17	-207	-50	-9	-38	-142	-6	-8	-209	-160	-21	-79	-47	-125	-9	-545
Murrieta	-17	-55	-11	-129	-31	-6	-24	-89	-4	-5	-131	-100	-13	-49	-29	-79	-6	-341
Needles	-2	-6	-1	-14	-3	-1	-3	-10	0	-1	-14	-11	-1	-5	-3	-9	-1	-37
Norwalk	-41	-131	-26	-305	-73	-13	-56	-209	-9	-12	-308	-236	-31	-116	-69	-185	-13	-804

	Riverside	Roseville	Sacramento	Salem	Salinas	San_Fransi	San_Bernad	San_Cleme	San_Diego	San_Jose	San_Juan_(	San_Luis_O	Santa_Ana	Santa_Bark	Santa_Clar	Seattle	SFO_Airpor	Solana_Bea
Oakland	-157	-500	-98	-1167	-280	-51	-216	-800	-33	-45	-1181	-904	-118	-446	-264	-709	-51	-3079
Oakland_Airport	-157	-500	-98	-1167	-280	-51	-216	-800	-33	-45	-1181	-904	-118	-446	-264	-709	-51	-3079
Oceanside	-63	-201	-40	-470	-113	-21	-87	-322	-13	-18	-476	-365	-48	-180	-107	-286	-21	-1241
Olympia-Lacey	-7	-22	-4	-51	-12	-2	-9	-35	-1	-2	-52	-40	-5	-20	-12	-31	-2	-136
Oroville	-5	-16	-3	-38	-9	-2	-7	-26	-1	-1	-38	-29	-4	-15	-9	-23	-2	-100
Palm_Springs	-17	-54	-11	-125	-30	-6	-23	-86	-3	-5	-127	-97	-13	-48	-28	-76	-6	-330
Palmdale_Airport	-46	-146	-29	-341	-82	-15	-63	-234	-10	-13	-345	-264	-35	-130	-77	-207	-15	-899
Pasadena	-52	-168	-33	-391	-94	-17	-72	-268	-11	-15	-396	-303	-40	-149	-89	-238	-17	-1032
Pasco	-15	-48	-9	-112	-27	-5	-21	-77	-3	-4	-113	-87	-11	-43	-25	-68	-5	-296
Pomona	-59	-187	-37	-437	-105	-19	-81	-299	-12	-17	-442	-338	-44	-167	-99	-265	-19	-1152
Portland	-16	-50	-10	-116	-28	-5	-21	-79	-3	-4	-117	-90	-12	-44	-26	-70	-5	-305
Red_Bluff	-5	-16	-3	-38	-9	-2	-7	-26	-1	-1	-39	-30	-4	-15	-9	-23	-2	-101
Redding	-32	-101	-20	-236	-57	-10	-44	-162	-7	-9	-239	-183	-24	-90	-54	-144	-10	-623
Redwood_City	-30	-94	-19	-220	-53	-10	-41	-151	-6	-8	-223	-171	-22	-84	-50	-134	-10	-581
Richmond	-39	-124	-24	-290	-70	-13	-54	-199	-8	-11	-293	-225	-29	-111	-66	-176	-13	-764
Riverbank	-6	-20	-4	-46	-11	-2	-9	-32	-1	-2	-47	-36	-5	-18	-10	-28	-2	-122
Riverside	189672	-319	-63	-745	-179	-33	-138	-511	-21	-29	-754	-578	-75	-285	-169	-453	-33	-1966
Roseville	-31	59339	-20	-233	-56	-10	-43	-160	-7	-9	-236	-181	-24	-89	-53	-142	-10	-616
Sacramento	-160	-509	302608	-1189	-285	-52	-220	-815	-33	-45	-1203	-921	-120	-454	-269	-722	-52	-3136
Salem	-13	-43	-8	25364	-24	-4	-18	-69	-3	-4	-101	-78	-10	-38	-23	-61	-4	-264
Salinas	-56	-179	-35	-417	106018	-18	-77	-286	-12	-16	-422	-323	-42	-159	-94	-253	-18	-1099
San_Fransisco	-304	-972	-191	-2269	-544	577572	-419	-1555	-63	-87	-2296	-1758	-230	-867	-514	-1379	-100	-5985
San_Bernadido	-73	-232	-46	-541	-130	-24	137772	-371	-15	-21	-548	-420	-55	-207	-123	-329	-24	-1428
San_Clemente	-20	-62	-12	-146	-35	-6	-27	37038	-4	-6	-148	-113	-15	-56	-33	-89	-6	-385
San_Diego	-479	-1531	-301	-3573	-857	-158	-660	-2450	909778	-137	-3617	-2769	-362	-1365	-810	-2171	-158	-9426
San_Jose	-351	-1120	-220	-2614	-627	-115	-483	-1793	-73	665627	-2646	-2026	-265	-999	-592	-1589	-115	-6897
San_Juan_Capistrano	-13	-42	-8	-99	-24	-4	-18	-68	-3	-4	25057	-77	-10	-38	-22	-60	-4	-261
San_Luis_Obispo	-17	-55	-11	-129	-31	-6	-24	-88	-4	-5	-131	32757	-13	-49	-29	-78	-6	-340
Santa_Ana	-132	-423	-83	-987	-237	-44	-182	-677	-28	-38	-999	-765	251260	-377	-224	-600	-44	-2604
Santa_Barbra	-35	-112	-22	-262	-63	-12	-48	-179	-7	-10	-265	-203	-27	66542	-59	-159	-12	-690
Santa_Clarita	-59	-189	-37	-441	-106	-19	-82	-303	-12	-17	-447	-342	-45	-169	112299	-268	-19	-1164
Seattle	-22	-70	-14	-165	-39	-7	-30	-113	-5	-6	-167	-128	-17	-63	-37	41803	-7	-434
SFO_Airport	-304	-972	-191	-2269	-544	-100	-419	-1555	-63	-87	-2296	-1758	-230	-867	-514	-1379	577572	-5985
Solana_Beach	-5	-16	-3	-38	-9	-2	-7	-26	-1	-1	-38	-29	-4	-14	-9	-23	-2	9553
Sparks	-9	-29	-6	-68	-16	-3	-13	-47	-2	-3	-69	-53	-7	-26	-15	-42	-3	-180
Spokane	-6	-19	-4	-45	-11	-2	-8	-31	-1	-2	-46	-35	-5	-17	-10	-27	-2	-119
Stockton	-96	-305	-60	-712	-171	-31	-131	-488	-20	-27	-721	-552	-72	-272	-161	-433	-31	-1878
Suisun-Fairfield	-10	-33	-6	-76	-18	-3	-14	-52	-2	-3	-77	-59	-8	-29	-17	-46	-3	-201
Sylmar	-2	-7	-1	-17	-4	-1	-3	-12	0	-1	-18	-13	-2	-7	-4	-11	-1	-46
Tacoma	-4	-14	-3	-32	-8	-1	-6	-22	-1	-1	-33	-25	-3	-12	-7	-20	-1	-86
Tahoe	-3	-11	-2	-26	-6	-1	-5	-18	-1	-1	-26	-20	-3	-10	-6	-16	-1	-68
Truckee	-5	-17	-3	-40	-10	-2	-7	-28	-1	-2	-41	-31	-4	-15	-9	-25	-2	-107
Turlock-Denair	-22	-70	-14	-163	-39	-7	-30	-112	-5	-6	-165	-126	-17	-62	-37	-99	-7	-430
Union_City	-26	-84	-16	-195	-47	-9	-36	-134	-5	-7	-198	-151	-20	-75	-44	-119	-9	-515
University_City	-26	-84	-16	-195	-47	-9	-36	-134	-5	-7	-198	-151	-20	-75	-44	-119	-9	-515
Van_Nuys	-27	-86	-17	-200	-48	-9	-37	-137	-6	-8	-202	-155	-20	-76	-45	-121	-9	-527
Vancouver	-35	-111	-22	-259	-62	-11	-48	-178	-7	-10	-262	-201	-26	-99	-59	-157	-11	-683
Ventura	-46	-147	-29	-342	-82	-15	-63	-235	-10	-13	-346	-265	-35	-131	-78	-208	-15	-903
Victorville	-25	-80	-16	-187	-45	-8	-35	-128	-5	-7	-189	-145	-19	-71	-42	-114	-8	-493
Wasco	-8	-27	-5	-62	-15	-3	-11	-43	-2	-2	-63	-48	-6	-24	-14	-38	-3	-164
Wenatchee	-2	-6	-1	-15	-4	-1	-3	-10	0	-1	-15	-11	-2	-6	-3	-9	-1	-39
Wilshram	-9	-28	-6	-66	-16	-3	-12	-46	-2	-3	-67	-51	-7	-25	-15	-40	-3	-175

ıch	Sparks	Spokane	Stockton	Suisun-Fair	Sylmar	Tacoma	Tahoe	Truckee	Turlock-De	Union_City	University_	Van_Nuys	Vancouver	Ventura	Victorville	Wasco	Wenatchee	Wilshram
Albany	-70	-107	-7	-63	-276	-148	-187	-119	-29	-25	-25	-24	-19	-14	-26	-77	-324	-72
Anaheim	-1402	-2126	-135	-1256	-5513	-2948	-3723	-2366	-588	-491	-491	-480	-370	-280	-512	-1543	-6466	-1442
Antioch-Pittsburgh	-387	-587	-37	-347	-1522	-814	-1027	-653	-162	-135	-135	-132	-102	-77	-141	-426	-1785	-398
Bakersfield	-1055	-1600	-101	-945	-4150	-2219	-2802	-1781	-442	-369	-369	-361	-279	-211	-386	-1161	-4867	-1086
Barstow	-90	-137	-9	-81	-355	-190	-240	-152	-38	-32	-32	-31	-24	-18	-33	-99	-416	-93
Bellingham	-10	-15	-1	-9	-40	-21	-27	-17	-4	-4	-4	-3	-3	-2	-4	-11	-47	-10
Berkeley	-439	-666	-42	-393	-1727	-924	-1166	-741	-184	-154	-154	-150	-116	-88	-160	-483	-2025	-452
Bingen-white_Salmon	-37	-56	-4	-33	-146	-78	-98	-63	-16	-13	-13	-13	-10	-7	-14	-41	-171	-38
Burbank	-429	-650	-41	-384	-1686	-902	-1139	-724	-180	-150	-150	-147	-113	-86	-157	-472	-1977	-441
Burbank_Airport	-429	-650	-41	-384	-1686	-902	-1139	-724	-180	-150	-150	-147	-113	-86	-157	-472	-1977	-441
Centrailia	-23	-34	-2	-20	-89	-48	-60	-38	-10	-8	-8	-8	-6	-5	-8	-25	-105	-23
Chemult	-103	-155	-10	-92	-403	-216	-272	-173	-43	-36	-36	-35	-27	-20	-37	-113	-473	-105
Chico	-259	-392	-25	-232	-1017	-544	-687	-436	-108	-90	-90	-88	-68	-52	-95	-285	-1193	-266
Colfax	-6	-10	-1	-6	-26	-14	-17	-11	-3	-2	-2	-2	-2	-1	-2	-7	-30	-7
Corcoran	-89	-135	-9	-80	-350	-187	-237	-150	-37	-31	-31	-30	-24	-18	-33	-98	-411	-92
Davis	-258	-391	-25	-231	-1014	-542	-684	-435	-108	-90	-90	-88	-68	-51	-94	-284	-1189	-265
Dunsmuir	-8	-12	-1	-7	-32	-17	-22	-14	-3	-3	-3	-3	-2	-2	-3	-9	-38	-8
Edmonds	-113	-172	-11	-102	-446	-239	-301	-191	-48	-40	-40	-39	-30	-23	-41	-125	-523	-117
Ephrata	-3	-5	0	-3	-13	-7	-9	-6	-1	-1	-1	-1	-1	-1	-1	-4	-15	-3
Escondido	-571	-866	-55	-512	-2246	-1201	-1517	-964	-239	-200	-200	-195	-151	-114	-209	-629	-2635	-588
Eugene	-39	-59	-4	-35	-154	-82	-104	-66	-16	-14	-14	-13	-10	-8	-14	-43	-181	-40
Everett	-112	-169	-11	-100	-439	-235	-297	-188	-47	-39	-39	-38	-29	-22	-41	-123	-515	-115
Fresno	-1828	-2771	-175	-1637	-7187	-3844	-4854	-3085	-766	-640	-640	-625	-482	-365	-668	-2011	-8430	-1880
Fullerton	-538	-817	-52	-482	-2118	-1133	-1430	-909	-226	-188	-188	-184	-142	-108	-197	-593	-2484	-554
Gilroy	-177	-269	-17	-159	-697	-373	-471	-299	-74	-62	-62	-61	-47	-35	-65	-195	-817	-182
Glendale	-833	-1263	-80	-747	-3277	-1753	-2213	-1406	-349	-292	-292	-285	-220	-166	-305	-917	-3843	-857
Hanford	-178	-270	-17	-160	-701	-375	-473	-301	-75	-62	-62	-61	-47	-36	-65	-196	-822	-183
Hinkle	-27	-41	-3	-24	-106	-57	-72	-46	-11	-9	-9	-9	-7	-5	-10	-30	-124	-28
Indio	-210	-318	-20	-188	-825	-441	-557	-354	-88	-73	-73	-72	-55	-42	-77	-231	-968	-216
Industry	-3	-5	0	-3	-13	-7	-9	-6	-1	-1	-1	-1	-1	-1	-1	-4	-15	-3
Irvine	-611	-927	-59	-548	-2405	-1286	-1624	-1032	-256	-214	-214	-209	-161	-122	-223	-673	-2820	-629
Kelso-Longview	-39	-60	-4	-35	-155	-83	-105	-67	-17	-14	-14	-13	-10	-8	-14	-43	-182	-41
Klamath_Falls	-87	-132	-8	-78	-341	-183	-231	-147	-36	-30	-30	-30	-23	-17	-32	-96	-401	-89
Los_Angeles	-15789	-23942	-1516	-14146	-62097	-33211	-41933	-26650	-6620	-5525	-5525	-5402	-4168	-3154	-5770	-17376	-72832	-16245
Madera	-185	-280	-18	-165	-726	-388	-490	-312	-77	-65	-65	-63	-49	-37	-67	-203	-852	-190
Martinez	-153	-232	-15	-137	-603	-322	-407	-259	-64	-54	-54	-52	-40	-31	-56	-169	-707	-158
Marysville	-52	-79	-5	-47	-206	-110	-139	-88	-22	-18	-18	-18	-14	-10	-19	-58	-242	-54
Merced	-273	-414	-26	-245	-1074	-574	-725	-461	-114	-96	-96	-93	-72	-55	-100	-300	-1259	-281
Modesto	-807	-1224	-77	-723	-3174	-1698	-2143	-1362	-338	-282	-282	-276	-213	-161	-295	-888	-3723	-830
Moorpark_Simi_Valley	-134	-204	-13	-120	-528	-282	-357	-227	-56	-47	-47	-46	-35	-27	-49	-148	-619	-138
Mt_Vernon	-302	-458	-29	-271	-1188	-636	-802	-510	-127	-106	-106	-103	-80	-60	-110	-333	-1394	-311
Murrieta	-189	-287	-18	-170	-744	-398	-503	-319	-79	-66	-66	-65	-50	-38	-69	-208	-873	-195
Needles	-21	-31	-2	-18	-81	-43	-55	-35	-9	-7	-7	-7	-5	-4	-8	-23	-95	-21
Norwalk	-446	-676	-43	-399	-1753	-938	-1184	-752	-187	-156	-156	-153	-118	-89	-163	-491	-2056	-459

ich	Sparks	Spokane	Stockton	Suisun-Fai	Sylmar	Tacoma	Tahoe	Truckee	Turlock-De	Union_City	University_	Van_Nuys	Vancouver	Ventura	Victorville	Wasco	Wenatchee	Wilshram
Oakland	-1708	-2589	-164	-1530	-6715	-3592	-4535	-2882	-716	-598	-598	-584	-451	-341	-624	-1879	-7876	-1757
Oakland_Airport	-1708	-2589	-164	-1530	-6715	-3592	-4535	-2882	-716	-598	-598	-584	-451	-341	-624	-1879	-7876	-1757
Oceanside	-688	-1044	-66	-617	-2707	-1448	-1828	-1162	-289	-241	-241	-235	-182	-137	-252	-757	-3174	-708
Olympia-Lacey	-75	-114	-7	-67	-296	-158	-200	-127	-32	-26	-26	-26	-20	-15	-27	-83	-347	-77
Oroville	-56	-84	-5	-50	-219	-117	-148	-94	-23	-19	-19	-19	-15	-11	-20	-61	-256	-57
Palm_Springs	-183	-277	-18	-164	-719	-385	-486	-309	-77	-64	-64	-63	-48	-37	-67	-201	-844	-188
Palmdale_Airport	-499	-756	-48	-447	-1961	-1049	-1324	-842	-209	-174	-174	-171	-132	-100	-182	-549	-2300	-513
Pasadena	-572	-868	-55	-513	-2251	-1204	-1520	-966	-240	-200	-200	-196	-151	-114	-209	-630	-2640	-589
Pasco	-164	-249	-16	-147	-645	-345	-436	-277	-69	-57	-57	-56	-43	-33	-60	-181	-757	-169
Pomona	-639	-969	-61	-572	-2512	-1344	-1696	-1078	-268	-224	-224	-219	-169	-128	-233	-703	-2946	-657
Portland	-169	-257	-16	-152	-666	-356	-450	-286	-71	-59	-59	-58	-45	-34	-62	-186	-781	-174
Red_Bluff	-56	-85	-5	-50	-221	-118	-149	-95	-24	-20	-20	-19	-15	-11	-21	-62	-259	-58
Redding	-346	-524	-33	-310	-1359	-727	-918	-583	-145	-121	-121	-118	-91	-69	-126	-380	-1594	-356
Redwood_City	-322	-489	-31	-289	-1267	-678	-856	-544	-135	-113	-113	-110	-85	-64	-118	-355	-1486	-332
Richmond	-424	-643	-41	-380	-1667	-892	-1126	-716	-178	-148	-148	-145	-112	-85	-155	-467	-1956	-436
Riverbank	-68	-103	-6	-61	-266	-142	-180	-114	-28	-24	-24	-23	-18	-14	-25	-74	-312	-70
Riverside	-1090	-1653	-105	-977	-4289	-2294	-2896	-1840	-457	-382	-382	-373	-288	-218	-399	-1200	-5030	-1122
Roseville	-342	-518	-33	-306	-1343	-718	-907	-576	-143	-120	-120	-117	-90	-68	-125	-376	-1575	-351
Sacramento	-1739	-2637	-167	-1558	-6841	-3659	-4619	-2936	-729	-609	-609	-595	-459	-347	-636	-1914	-8023	-1790
Salem	-146	-222	-14	-131	-575	-308	-389	-247	-61	-51	-51	-50	-39	-29	-53	-161	-675	-151
Salinas	-610	-925	-59	-546	-2398	-1283	-1619	-1029	-256	-213	-213	-209	-161	-122	-223	-671	-2813	-627
San_Fransisco	-3319	-5033	-319	-2974	-13054	-6982	-8815	-5603	-1392	-1162	-1162	-1136	-876	-663	-1213	-3653	-15311	-3415
San_Bernadido	-792	-1201	-76	-710	-3116	-1666	-2104	-1337	-332	-277	-277	-271	-209	-158	-290	-872	-3654	-815
San_Clemente	-213	-324	-20	-191	-839	-449	-567	-360	-89	-75	-75	-73	-56	-43	-78	-235	-984	-220
San_Diego	-5228	-7928	-502	-4684	-20562	-10997	-13885	-8824	-2192	-1830	-1830	-1789	-1380	-1044	-1911	-5754	-24116	-5379
San_Jose	-3825	-5800	-367	-3427	-15044	-8046	-10159	-6457	-1604	-1339	-1339	-1309	-1010	-764	-1398	-4210	-17645	-3936
San_Juan_Capistrano	-145	-219	-14	-130	-569	-304	-384	-244	-61	-51	-51	-49	-38	-29	-53	-159	-667	-149
San_Luis_Obispo	-189	-286	-18	-169	-743	-397	-501	-319	-79	-66	-66	-65	-50	-38	-69	-208	-871	-194
Santa_Ana	-1444	-2190	-139	-1294	-5680	-3038	-3836	-2438	-606	-505	-505	-494	-381	-289	-528	-1590	-6662	-1486
Santa_Barbra	-383	-581	-37	-343	-1506	-805	-1017	-646	-161	-134	-134	-131	-101	-76	-140	-421	-1766	-394
Santa_Clarita	-646	-979	-62	-579	-2540	-1358	-1715	-1090	-271	-226	-226	-221	-170	-129	-236	-711	-2979	-664
Seattle	-241	-365	-23	-216	-947	-506	-639	-406	-101	-84	-84	-82	-64	-48	-88	-265	-1111	-248
SFO_Airport	-3319	-5033	-319	-2974	-13054	-6982	-8815	-5603	-1392	-1162	-1162	-1136	-876	-663	-1213	-3653	-15311	-3415
Solana_Beach	-55	-84	-5	-50	-218	-117	-147	-94	-23	-19	-19	-19	-15	-11	-20	-61	-256	-57
Sparks	17303	-152	-10	-90	-393	-210	-266	-169	-42	-35	-35	-34	-26	-20	-37	-110	-461	-103
Spokane	-66	11377	-6	-59	-259	-139	-175	-111	-28	-23	-23	-23	-17	-13	-24	-73	-304	-68
Stockton	-1042	-1580	181197	-933	-4097	-2191	-2767	-1758	-437	-365	-365	-356	-275	-208	-381	-1146	-4805	-1072
Suisun-Fairfield	-112	-169	-11	19324	-439	-235	-296	-188	-47	-39	-39	-38	-29	-22	-41	-123	-515	-115
Sylmar	-25	-39	-2	-23	4325	-53	-68	-43	-11	-9	-9	-9	-7	-5	-9	-28	-117	-26
Tacoma	-48	-72	-5	-43	-187	8174	-126	-80	-20	-17	-17	-16	-13	-9	-17	-52	-219	-49
Tahoe	-38	-57	-4	-34	-148	-79	6453	-64	-16	-13	-13	-13	-10	-8	-14	-41	-174	-39
Truckee	-59	-90	-6	-53	-233	-125	-157	10211	-25	-21	-21	-20	-16	-12	-22	-65	-273	-61
Turlock-Denair	-239	-362	-23	-214	-938	-502	-633	-403	41408	-83	-83	-82	-63	-48	-87	-262	-1100	-245
Union_City	-286	-433	-27	-256	-1124	-601	-759	-482	-120	49632	-100	-98	-75	-57	-104	-314	-1318	-294
University_City	-286	-433	-27	-256	-1124	-601	-759	-482	-120	-100	49632	-98	-75	-57	-104	-314	-1318	-294
Van_Nuys	-292	-443	-28	-262	-1149	-615	-776	-493	-123	-102	-102	50765	-77	-58	-107	-322	-1348	-301
Vancouver	-379	-574	-36	-339	-1490	-797	-1006	-639	-159	-133	-133	-130	65825	-76	-138	-417	-1747	-390
Ventura	-501	-759	-48	-449	-1969	-1053	-1330	-845	-210	-175	-175	-171	-132	87025	-183	-551	-2309	-515
Victorville	-274	-415	-26	-245	-1076	-576	-727	-462	-115	-96	-96	-94	-72	-55	47520	-301	-1262	-282
Wasco	-91	-138	-9	-81	-357	-191	-241	-153	-38	-32	-32	-31	-24	-18	-33	15714	-419	-93
Wenatchee	-22	-33	-2	-19	-85	-46	-58	-37	-9	-8	-8	-7	-6	-4	-8	-24	3673	-22
Wilshram	-97	-147	-9	-87	-382	-204	-258	-164	-41	-34	-34	-33	-26	-19	-36	-107	-448	16815

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